

Understanding
GENERAL
EMBRYOLOGY

BY
DR. SAMEH DOSS (Ph.D)

PROFESSOR OF ANATOMY
FACULTY OF MEDICINE, CAIRO UNIVERSITY

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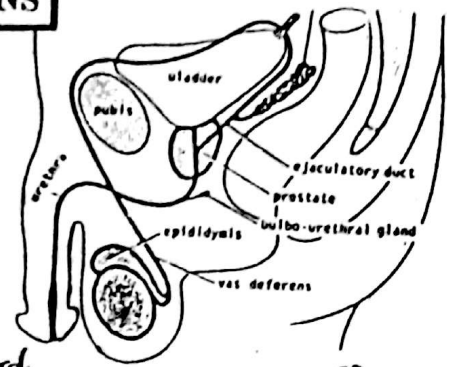
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I- Male Genital organs

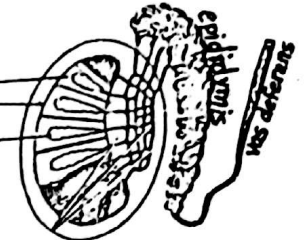
- (a) the testis
- (b) genital ducts
- (c) accessory glands

(A) The Testis:

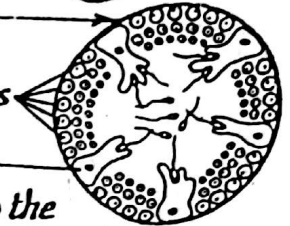
- * It is the male 1^{st} sex organ which produces the sperms & secretes the male sex hormone
- * site: it lies in the scrotum suspended by the spermatic cord.
- * structure:
 - it consists of about 250 compartments (lobules).
 - each compartment contains 2-3 highly coiled seminiferous tubules.
 - each seminiferous tubule has:



- (a) an outer fibrous basement membrane
- (b) 2 types of cells lying on the basement membrane:
 - (1) spermatogonia: the most primitive germ cells
 - (2) Sertoli cells: supporting cells



- ### (B) the male genital ducts:
- conduct the sperms from the testis to the urethra & include:
- (1) the epididymis (highly coiled duct behind the testis)
 - (2) the vas deferens (in the spermatic cord) which ends by uniting with the duct of the seminal vesicle forming the ejaculatory duct which opens into prostatic urethra



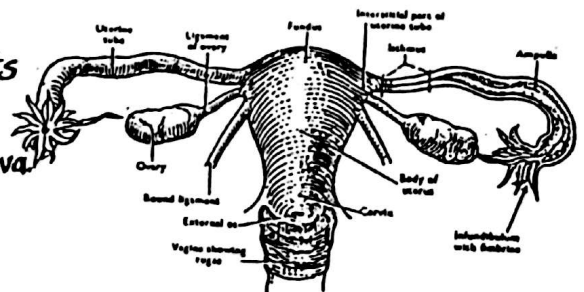
- ### (C) Accessory glands:
- secrete nutritive secretions for the sperms & include:
- (1) seminal vesicles (2) the prostate (3) bulbourethral glands.

II- Female Genital organs

- (a) the ovary
- (b) genital ducts

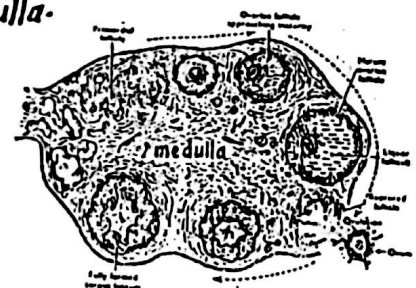
(A) The ovary:

- * it is the female 1^{st} sex organ which produces the ova & secretes female sex hormones.
- * site: it lies on the side wall of the pelvis
- * structure: it consists of an outer cortex & an inner medulla.
 - the cortex: contains the ovarian follicles which undergo maturation to produce the ova.
 - the medulla: consists of a vascular connective tissue.



(B) The genital ducts: consist of:

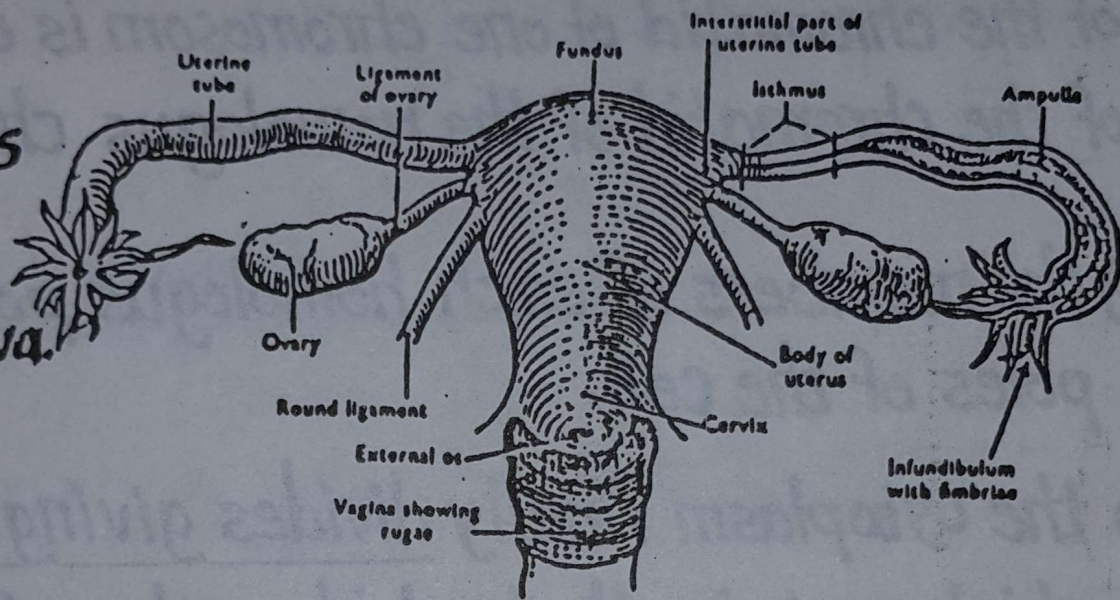
- (1) Fallopian tube: transmits the ovum to the uterus.
- (2) uterus: a pear-shaped muscular organ in which the embryo develops. It consists of:
 - (a) Fundus: the dome-shaped part above the attachment of the Fallopian tubes.
 - (b) body: the main part of the uterus. Its lower narrow part is called the isthmus.
 - (c) cervix: is the lower end of the uterus which bulges into the vagina.
- (3) Vagina: is the birth & copulatory canal.



cord) which ends by uniting with the duct
 circulatory duct which opens into prostatic urethra
 secretions for the sperms & include:
 (2) the prostate (3) bulbourethral glands.

Vary
 al ducts

es the ova.

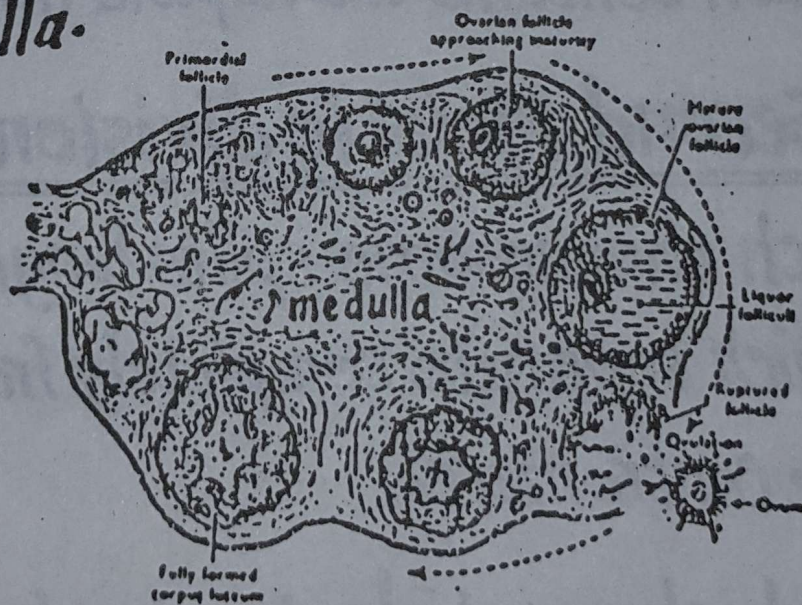


& an inner medulla.

which undergo

ective tissue.

the uterus.



n in which the embryo develops. It consists of:

the attachment of the Fallopian tubes.

lower narrow part is called the isthmus.

which bulges into the vagina.

* **Definition** : it is the process of production of mature gametes (sperms & ova) by the gonads.

* **Sites** : it occurs in the gonads (testes & ovaries).

* **Mechanism** : gametogenesis entails changes in the cytoplasm & the nucleus of the primitive germ cells (spermatogonia & oogonia) as follows :

(1) the cytoplasm : is greatly increased in the ovum but greatly decreased in the sperms

(2) the nucleus : undergoes Meiotic division to reduce the number of chromosomes to its half.

MEIOTIC DIVISION

* **Definition** : it is a type of cellular division resulting in reduction of the number of chromosomes from the diploid number (46) to the haploid number (23).

* **Occurance** : it occurs in the primitive sex cells only (spermatogonia & oogonia).

* **Steps** : it occurs in 2 successive stages called the 1st meiotic & the 2nd meiotic division.

(A) - First meiotic division :

(1) the 46 chromosomes in the nucleus of the dividing primitive sex cell are arranged in 23 pairs (each pair consists of 2 homologous chromosomes)

(2) each chromosome reduplicates itself i.e splits longitudinally into 2 chromatids which remain attached to the centromere.

(3) breaks occur in the chromatids & crossing over takes place i.e a segment of the chromatid of one chromosome is exchanged with equally sized segment of the chromatid of the homologous chromosome.

(4) the members of each homologous pair separate & migrate to the opposite poles of the cell.

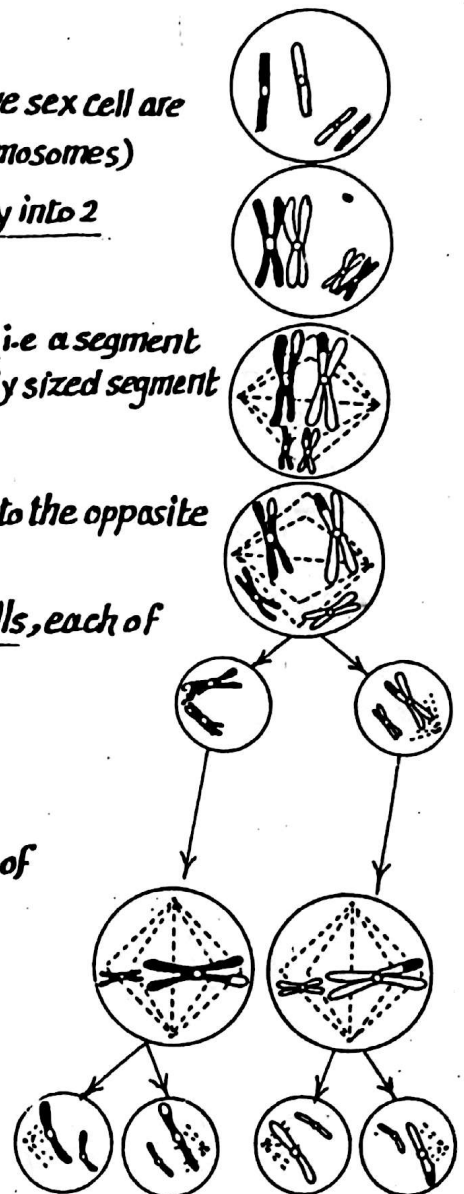
(5) the cytoplasm finally divides giving rise to 2 daughter cells, each of which contains the haploid number of chromosomes i.e 23.

(B) Second Meiotic division :

(1) each chromosome splits longitudinally into 2 chromatids which separate completely from each other due to splitting of the centromere.

(2) each chromatid migrates into one pole of the cell & develops into a full chromosome.

(3) the cytoplasm then divides resulting in the splitting of the cell into 2 daughter cells, each of which contains 23 chromosomes.



* Results of Meiosis : the end result of the 2 stages of meiosis is : **3**

- (1) formation of 4 daughter cells from one primitive sex cell.
- (2) reduction of the number of chromosomes in each daughter cell into 23.

* Abnormalities which may occur during Meiosis :

Non-disjunction :

- Definition : it is the failure of the 2 members of a pair of homologous chromosomes to separate during the 1st meiotic division and thus they pass together to one of the 2 daughter cells. Non-disjunction may also occur during the 2nd meiotic division due to failure of separation of the 2 chromatids as a result of non splitting of the centromere.

- Results of non-disjunction :

- (a) as a result of non-disjunction of chromosomes in the mother cell, one daughter cell will have an extra chromosome (i.e 24) while the other daughter cell will have one chromosome less (i.e 22).
- (b) when fertilization of such cells with abnormal chromosomal number takes place, the following may occur:
 - (1) when a gamete with 24 chromosomes unites with a normal gamete (23 chromosomes) the resulting zygote will have 47 (instead of 46) chromosomes. This condition is called Trisomy because one chromosome is present in triple instead of being double.
 - (2) when a gamete with 22 chromosomes unites with a normal gamete (23 ch.), the resulting zygote will have only 45 chromosomes. This condition is called Monosomy because one chromosome is present in single form instead of being double.

* Examples of Trisomy & Monosomy :

(1) Trisomy of the chromosome 21 : the condition is called Down's syndrome. The baby has characteristic facies & short broad hands.



(2) Trisomy of the x-chromosome : this occurs when an ovum contains 2x chromosomes (instead of one, due to non-disjunction) is fertilized by an -x sperm producing xxx zygote.

(3) Monosomy of the x-chromosome : this case occurs when an ovum with no x chromosome is fertilized by an x-sperm resulting in the formation of an xo zygote. This condition is called Turner's Syndrome.

SPERMATOGENESIS

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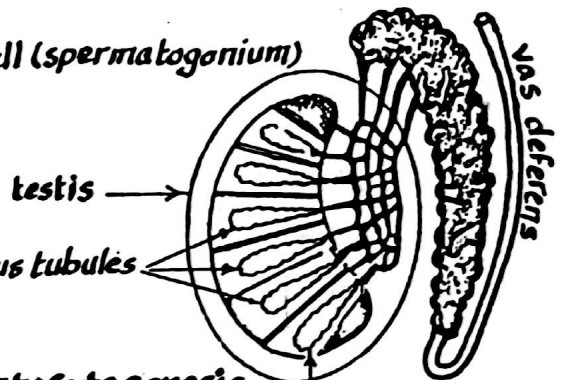
* **Definition:** it is the process of formation of sperms in the seminiferous tubules of the testis.

* **Aim of Spermatogenesis:**

- (1) reduction of the number of chromosomes from the diploid number (46) to the haploid number (23) by meiosis.
- (2) change in the shape of the male germ cell to produce a highly motile sperm ready for fertilization of the ovum.
- (3) increase in the number of cells so that one mother cell (spermatogonium) produces 8 sperms.

* **Occurance:**

Spermatogenesis occurs continuously in the seminiferous tubules of the testis starting from puberty till old age.

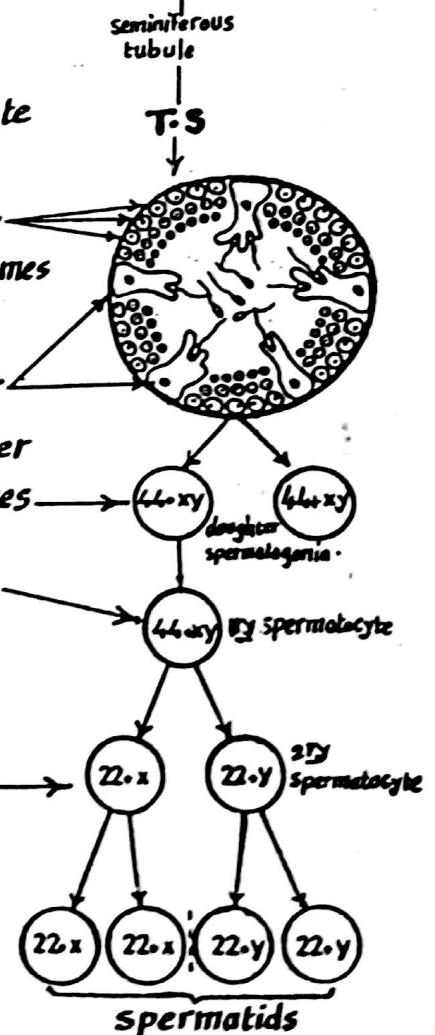


* **Stages of Spermatogenesis**
 Spermatocytogenesis.
 Spermiogenesis.

(A) **Spermatocytogenesis:**

* It is the process by which the spermatogonia differentiate into spermatids as follows:

- the spermatogonia are the most primitive male germ cells.
- they contain the diploid number of chromosomes (44 autosomes + 2 sex chromosomes X & Y). They lie in the wall of the seminiferous tubules of the testis supported by Sertoli cells.
- each spermatogonium undergoes mitotic division to give 2 daughter spermatogonia each of which contains 44 + XY chromosomes
- Each daughter spermatogonium grows to give 1st spermatocyte
- the 1st spermatocyte undergoes Meiotic division to give 2 secondary spermatocytes each of which contains the haploid number of chromosomes : 22 + X or 22 + Y
- Each 2nd spermatocyte undergoes mitosis to give 2 spermatids thus 4 spermatids are formed from each daughter spermatogonium.

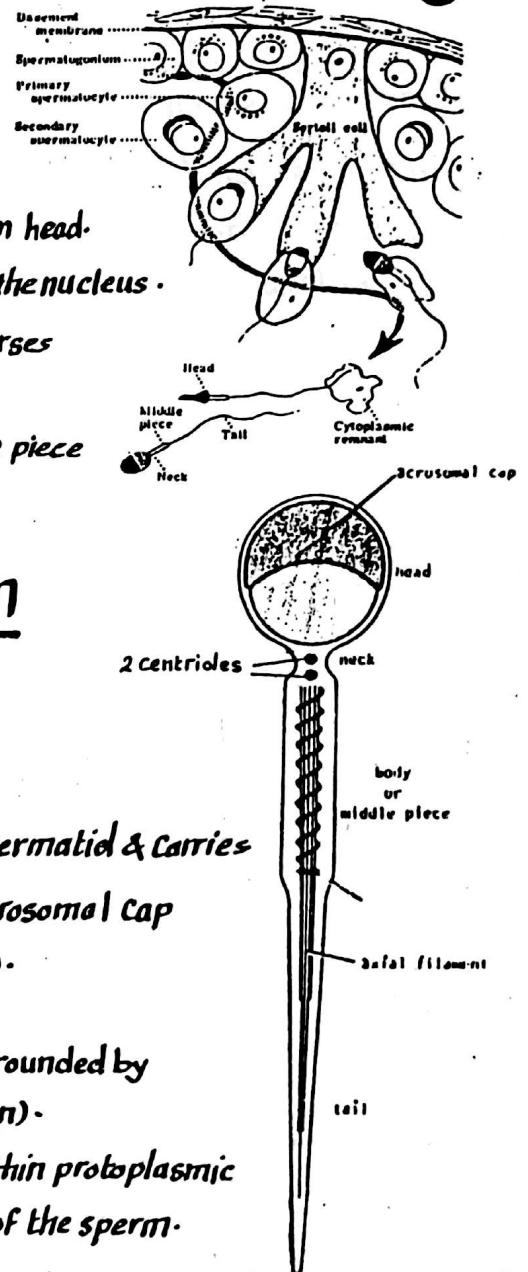


(B) Spermiogenesis:

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- the spermatid, which is a rounded cell, undergoes metamorphosis (morphological & structural changes) to become transformed into a mature sperm as follows:

- (1) the nucleus becomes condensed & forms most of the sperm head.
- (2) Golgi apparatus forms the head cap covering the ant. $\frac{1}{2}$ of the nucleus.
- (3) the centriole elongates to form the axial filament which traverses the neck, middle piece & tail of the sperm.
- (4) the mitochondria form a spiral sheath around the middle piece.
- (5) Finally, the remainder of the cytoplasm is shed.



The mature Sperm

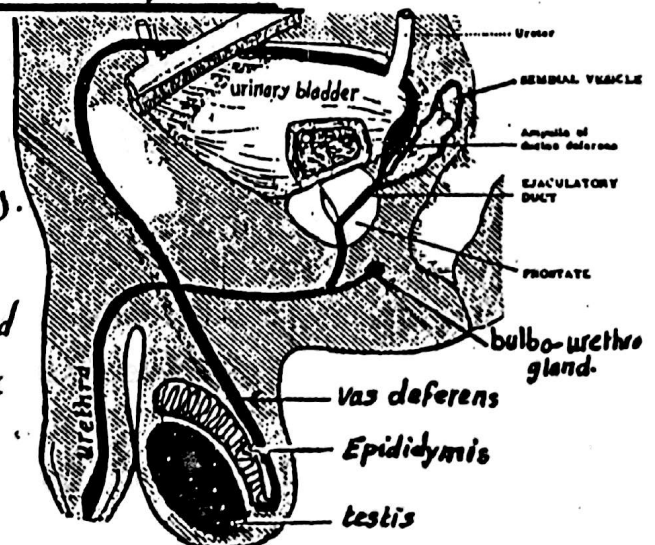
* Size: 60 microns long.

* Structure: it is formed of the following parts:

- (1) head: 5μ : it is formed mainly by the nucleus of the spermatid & carries the genetic informations. Its ant. $\frac{1}{2}$ is covered by the acrosomal cap which contains enzymes to help penetration of the ovum.
- (2) Neck: very short & contains 2 centrioles.
- (3) middle piece: 5μ : formed by an axial filament surrounded by a mitochondrial sheath (concerned with energy production).
- (4) tail: 50μ long: formed of axial filament covered by a thin protoplasmic membrane & is concerned with mobility of the sperm.

The transport & fate of the sperms

the sperms leave the testis to reach the epididymis (for physiological maturation).
 - then they reach the vas-deferens waiting for ejaculation - in its dilated end (ampulla of vas).
 - when ejaculation occurs the sperms pass through the urethra where they become deposited in the vagina $\rightarrow$ ascend through the cervix $\rightarrow$ cavity of the uterus $\rightarrow$ enter the Fallopian tube to reach its lateral part.



- * If no ovum is found in the Fallopian tube at the time of ejaculation, the sperms remain for 96 hours then die. The fertilizing power of the sperms is lost about 42 hours after ejaculation.
- * If no ejaculation occurs, the stored sperms inside the vas deferens die & become absorbed.

The Seminal Fluid (Semen)

- * Nature: it is the fluid containing the sperms suspended in the secretions of the seminal vesicles, prostate & the bulbo-urethral glands.
- * Characters: it is thick white opaque gelatinous fluid.
it has a characteristic odour & is alkaline in reaction.
- * Volume: 3-5 c.c per ejaculation (normally not less than 1.5 c.c.).
- * Number of sperms: 200-300 millions per ejaculation.
- * Motility: normally 60-70% of all sperms are motile.

* Abnormalities:



(1) abnormalities in shape: the abnormalities may affect the head or the tail.

The sperms may be too small (dwarfs) or too big (giants), with 2 heads (bicephalic) or with 2 tails (bicaudal).

N.B normally, the abnormal forms do not exceed 10% of the total sperm count.

If more than 25% of total sperms are abnormal, fertility will be impaired.

(2) Abnormalities in number:

(a) oligospermia: the number of sperms is below normal.

(b) azospermia: Complete absence of sperms in the semen.

(3) Necropermia: is the presence of dead sperms in the semen.

Oogenesis

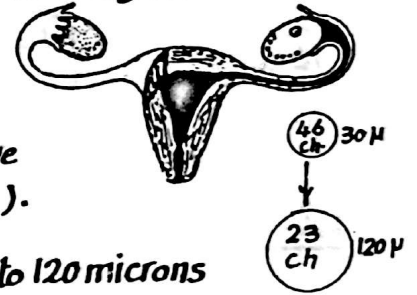
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***Definition:** it is the process of production of a mature ovum ready for fertilization by the sperm.

***Site :** oogenesis occurs in the cortex of the ovary.

***Aim :** (i) reduction of the number of chromosomes from the diploid number (46) to the haploid number (23).

(2) increase of the size of the ovum from 30 microns to 120 microns



***Age incidence :** oogenesis occurs during the fertile period of the female i.e. starting from puberty (11-14 years) & ending at menopause (40-45 years). During this fertile period, one mature ovum is developed in the ovary (Rt. or Lt.) every 28 days.

***Mechanism (steps):**

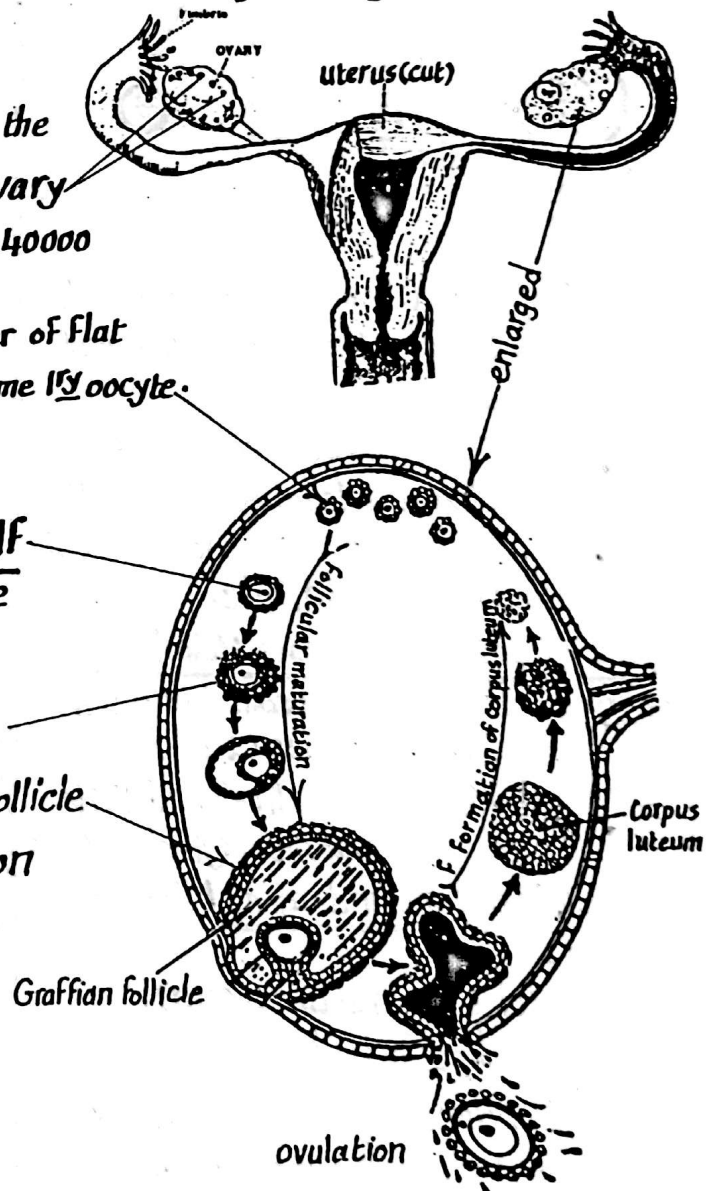
- the primitive female germ cells are called the oogonia which lie in the cortex of the ovary
- At puberty, each ovary contains about 40000 oogonia.
- each oogonium is surrounded by a layer of flat epithelial cells called follicular cells to become 1st oocyte.

- Oogenesis includes 2 processes :

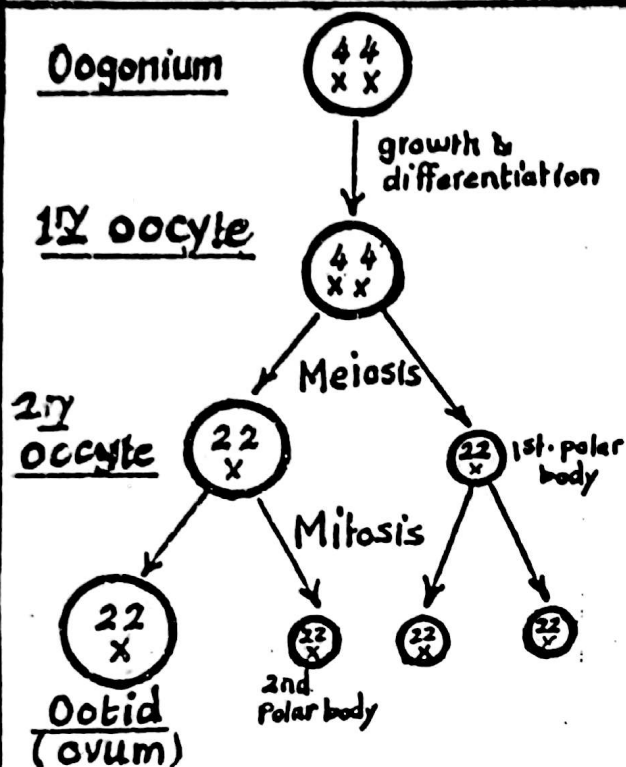
(1) **Maturation of the 1st oocyte itself** to become a mature ovum containing the haploid number of chromosomes.

(2) **Maturation of the follicular cells**

around the oocyte to become a mature follicle for protection of the ovum & production of hormones.

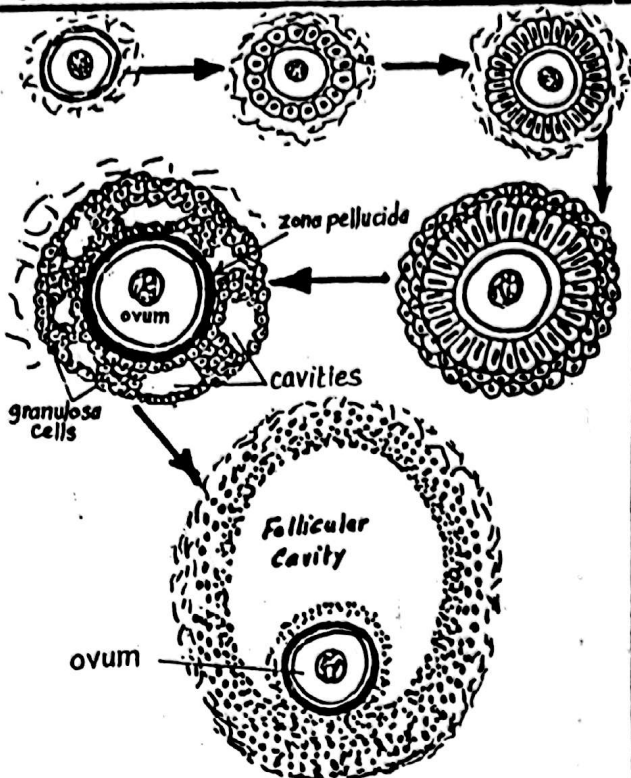


Development of the Oogonium (Oogenesis)



Development of follicular cells (Formation of Graffian Follicle)

8



- (1) the oogonium (the most primitive female germ cell) contains the diploid number of chromosomes ($44 + XX$).
- (2) it grows & becomes surrounded by single layer of follicular cells to become the **1st Oocyte**. The 1st oocyte + the follicular cells are called the **1st Follicle**.
- (3) the **1st oocyte** undergoes Meiosis to give:
 - (a) **2nd oocyte**: a large cell containing 23 chromosomes ($22 + X$).
 - (b) **1st polar body**: a small cell with little amount of cytoplasm ($22 + X$).
- (4) the **2nd oocyte** undergoes Mitosis to give:
 - (a) **Ootid** (the mature ovum).
 - (b) the **2nd polar body**.
- (5) the **1st polar body** divides into 2 by mitosis, then the 3 polar bodies disappear.

- (1) the simple flat epithelial cells which surround the 1st oocyte start to enlarge & become cuboidal then simple columnar which divide forming many layers around the oocyte.
- (2) the follicular cells deposit a glycoprotein substance which surrounds the oocyte & is known as Zona pellucida & the follicular cells are now called **granulosa cells**.

(3) Formation of the Graffian Follicle:

small irregular spaces appear between the granulosa cells & later join each other to form one large cavity (the follicular cavity) which is filled with the follicular fluid that is secreted by the follicular cells & contains oestrogenic hormones. This structure is called the **Graffian Follicle**.

The Mature Graffian Follicle:

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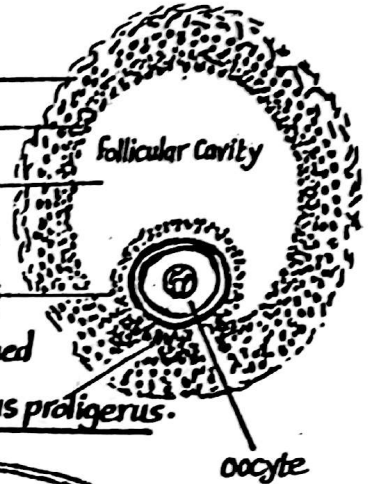
* It is the end result of the growth of the 1st follicle (the 1st oocyte surrounded by a single layer of follicular cells).

* Site: in the cortex of the ovary very close to its surface.

* Size: $\frac{1}{2}$ to 1 cm.

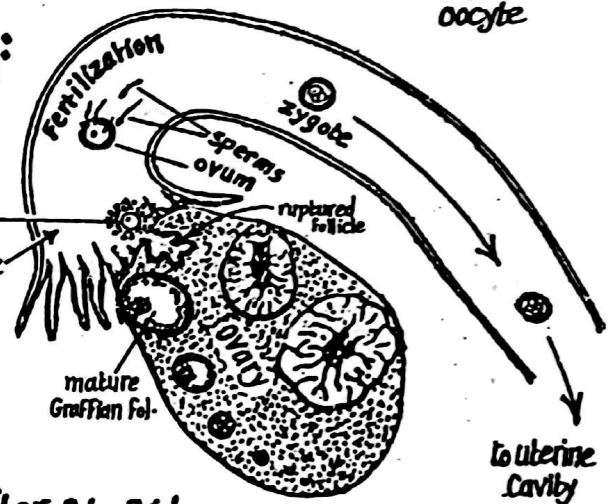
* Shape & Structure: it is a spherical vesicle formed of:

- (1) Follicular wall formed of 2 layers
 $\left\{ \begin{array}{l} \text{outer fibrous (theca externa)} \\ \text{inner vascular (theca interna)} \end{array} \right.$
- (2) Follicular cavity: crescent-shaped & filled with follicular fluid
(containing oestrogen & secreted by the follicular cells).
- (3) the Oocyte: surrounded by follicular cells called cumulus oophorus
& having an eccentric position in the follicle (attached to the wall of the vesicle by collection of cells called discus proligerus).



* Fate of Graffian follicle & the ovum:

- (1) the mature Graffian follicle ruptures at the time of ovulation releasing the mature ovum which is sucked into the Fallopian (uterine) tube where it lies waiting for fertilization.
- (2) if fertilization of the ovum takes place, the zygote is formed.
- (3) if No fertilization occurs, the ovum dies after 24-36 hours.
- (4) the ruptured Graffian follicle is transformed into a yellow body called Corpus luteum, the fate of which depends on whether fertilization occurs or not (see page 11).

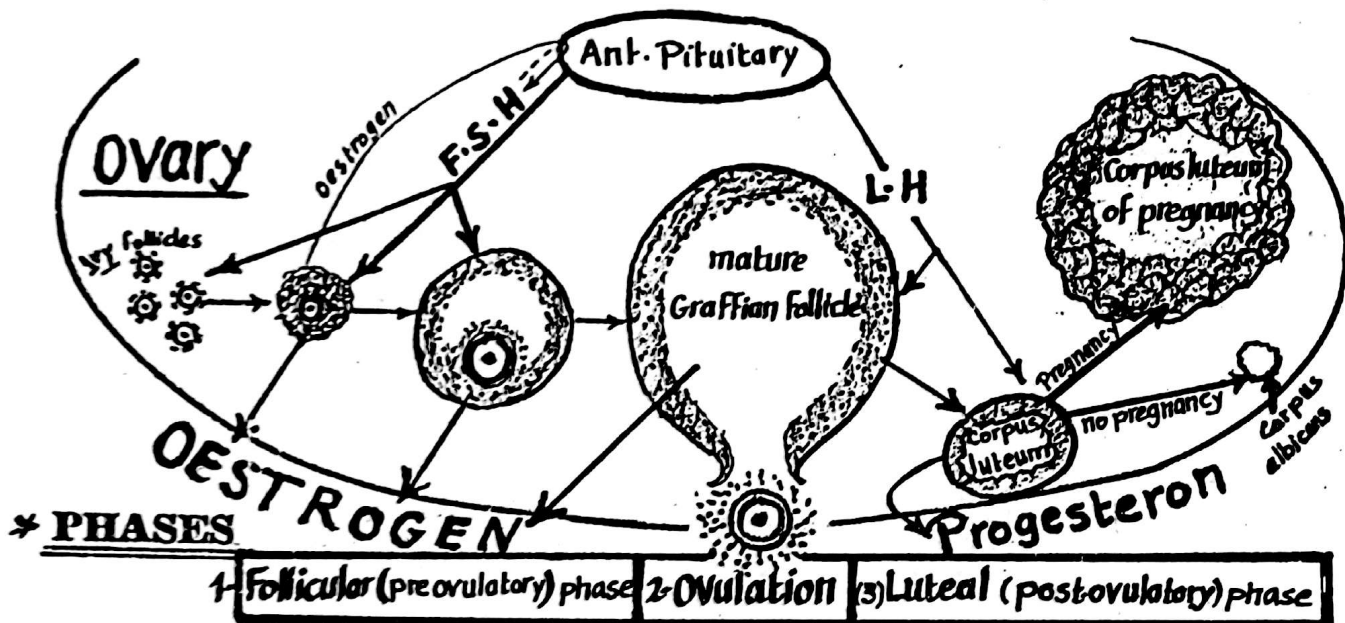


N.B: At ovulation, the ovum is released from the ruptured Graffian follicle with some layers of follicular cells around it, called Corona radiata.

OVARIAN CYCLE

10

***Definition :** It is the periodic changes occurring in the ovary during the fertile period which starts at puberty (11-14 years) & ends at menopause (40-45 years)



A- Follicular (Pre-ovulatory) Phase: (the 1st $\frac{1}{2}$ of the ovarian cycle):

- (1) At the beginning of each ovarian cycle, the ant. lobe of pituitary gland secretes Follicle Stimulating Hormone (F.S.H).
- (2) The F.S.H stimulates a number of 1^{ry} follicles to mature.
- (3) One follicle usually reaches full maturity before the others.
- (4) The growing follicle secretes oestrogen Feed back mechanism → Ant. pituitary → stopping of secretion of F.S.H → degeneration of the other 1^{ry} follicles
- (5) The Oestrogen secreted by the growing follicle in this phase reaches the Uterus by blood & is responsible for the proliferative changes of the endometrium of uterus in the Uterine cycle.

B- OVULATION:

*** It is the release of the ovum from the mature Graafian follicle due to its rupture on the surface of the ovary.**

*** Time of ovulation :** Ovulation occurs in the middle of the ovarian cycle (once every lunar month i.e 28 days)

* the exact time of ovulation is approximately 14 days (± 1 day) **11**
before the beginning of the next menstruation

N.B ① Ovulation does not occur during pregnancy & occurs to a lesser extent during lactation.

② At the time of ovulation the body temperature is slightly elevated.

(C) The Luteal (Post-Ovulatory) Phase (the 2nd $\frac{1}{2}$ of the cycle)

- (1) Under the effect of the Luteinising Hormone (L.H) of ant. pituitary, the ruptured Graffian follicle is transformed into a yellow body called the Corpus luteum.
- (2) The Corpus luteum secretes progesterone which is carried to the uterus by blood & is responsible for secretory phase of endometrium in the uterine cycle.
- (3) The fate of the Corpus luteum: depends on whether fertilization & pregnancy occurs or not:
 - (a) If fertilization does not occur: the Corpus luteum lives for 9 days only then decreases in size & degenerates & is transformed into a small mass of fibrous tissue called Corpus Albicans. The degeneration of the Corpus luteum leads to decrease in the level of progesterone in blood.
 - (b) If fertilization occurs
 - The developing embryo secretes gonadotrophic hormones $\longrightarrow$ stimulates the Corpus luteum to grow forming a large structure called Corpus Luteum of pregnancy which by the end of the 3rd month reaches $\frac{1}{3}$ to $\frac{1}{2}$ the size of the ovary.
 - the Corpus luteum of pregnancy remains for months & secretes progesterone which is essential to maintain the pregnancy.
 - At the end of the 4th month of pregnancy the placenta takes over the function of the Corpus luteum which begins to degenerate slowly.

The Uterine (Menstrual) Cycle

12

*** Definition:** It is the cyclic changes occurring in the endometrium (mucous memb.) of the uterus every lunar month (28 days) in response to the cyclic changes which occur simultaneously in the ovary during the ovarian cycle.

* Phases:

- (1) Menstrual phase.
- (2) Post-menstrual or proliferative phase.
- (3) Pre-menstrual or secretory phase.

I. Menstrual Phase (menstruation)

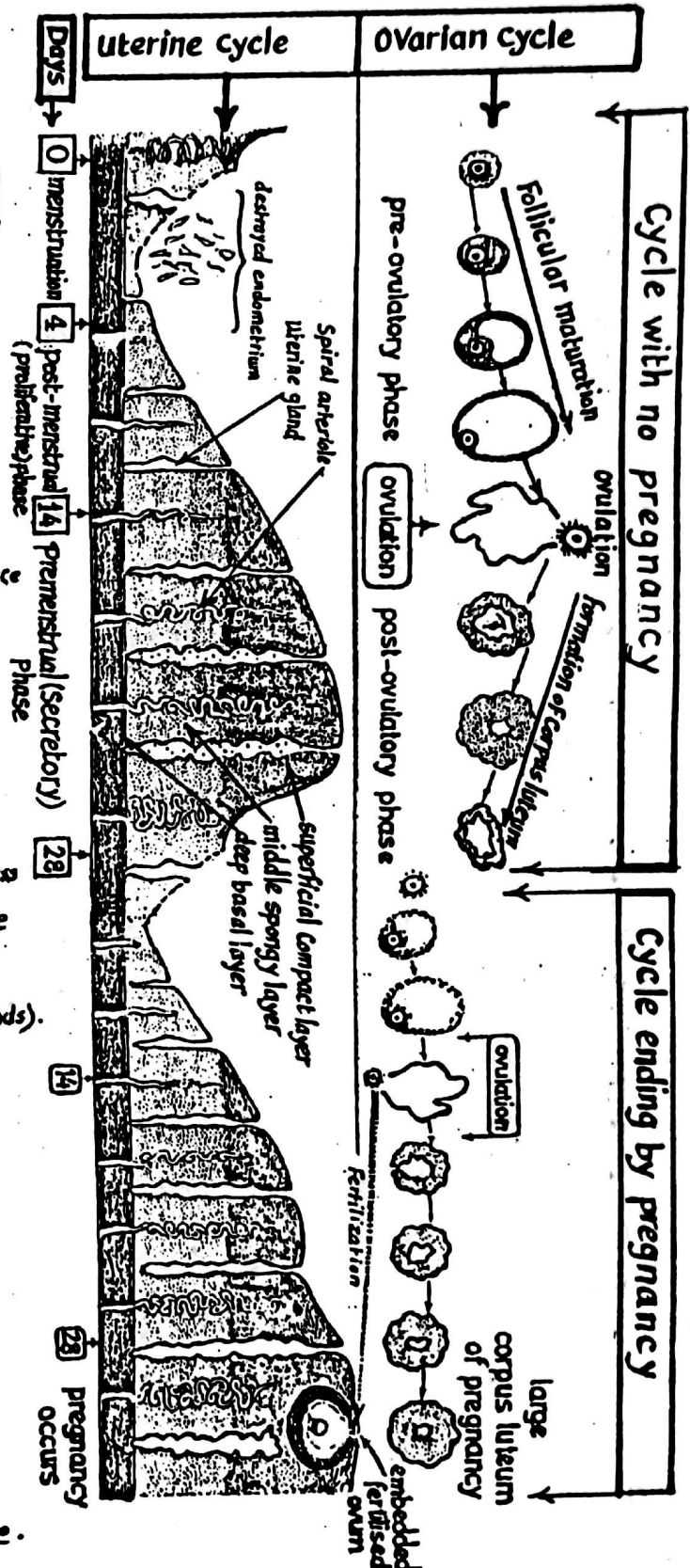
- Duration: 3-5 days. The first day of bleeding is considered the 1st day of the cycle.

- Events:

- * the superficial layers of endometrium are destroyed & shed with the discharge of 50-60 C.C. of blood from the denuded surface
- * the discharged blood containing destroyed endometrium comes out of vagina unclotted due to the presence of proteolytic enzymes which prevent coagulation.
- * at the end of this phase the endometrium is reduced to $\frac{1}{5}$ to $\frac{1}{10}$ of its maximal thickness due to loss of its superficial compact & middle spongy layers leaving the deep basal layer intact (contains the stumps of the uterine glands).

- Cause of menstruation:

Sudden drop of the hormones (mainly progesterone) secreted by the Corpus luteum due to its atrophy at the end of the luteal phase of the ovarian cycle $\rightarrow$ vaso spasm of the spiral arterioles supplying the endometrium $\rightarrow$ necrosis & shedding of the superficial layers with discharge of blood from the denuded (wounded) surface.



II- Postmenstual (Proliferative) Phase = $\begin{cases} \text{oestrogenic} \\ \text{or} \\ \text{Follicular phase} \end{cases}$

13

*Duration : 10 days (It coincides with the follicular phase of the ovarian cycle.)

*Events:

- (1) The wound in the uterus heals by epithelial cells (from the remaining stumps of the uterine glands) which start to proliferate to repair the shed endometrium (this is why it is called proliferative phase).
- (2) By the 5th day, the surface endometrium becomes totally covered by the epithelial cells.
- (3) the endometrial glands appear straight.
- (4) At the end of this phase the glands become tortuous & the endometrium becomes differentiated into 3 layers :
 - (a) Superficial Compact layer : Containing the mouths of the glands.
 - (b) Intermediate Spongy : Containing the dilated tortuous middle part of the glands.
 - (c) Deep basal layer : contains the basal part of the glands.

*Causes of the Changes in the proliferative phase:

The Oestrogen secreted by the graffian follicle is responsible for the proliferative changes (this is why it is also called oestrogenic phase).

III- Premenstual (Secretory or luteal) Phase :

*Duration: About 13 days (occurring before the next menstruation, hence the name
It coincides with the luteal phase of the ovarian cycle.

*Events:

- (1) the endometrium increases in thickness.
- (2) the endometrial glands become more tortuous & filled with secretions rich in glycogen & mucin (this is why this phase is called secretory phase)
- (3) the endometrial arteries : become tortuous and called the spiral arteries.

*Causes of these changes: the progesterone secreted by the Corpus luteum is responsible for these changes.

The Intra-uterine life

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* It is the time that elapses between fertilization and the birth of a new individual. It is about 10 lunar months (280 days).

* the Intra uterine life of the individual is divided into 3 Stages

Period	Germinal period	Embryonic period	Foetal period
Duration	* The 1 st 2 weeks	From the beginning of the 3 rd week till 3 rd month	From the beginning of 3 rd month to the end of pregnancy
Characters	It is characterized by the formation of the 3 germ layers : ectoderm, endoderm & mesoderm	It is characterized by the differentiation of the 3 germ layers into organs & systems	characterized by the growth of the various organs & systems & the gradual appearance of the external features of the foetus
Congenital anomalies	Congenital anomalies are liable to occur during the germinal & embryonic periods		Congenital anomalies are less liable to occur

The First Week of pregnancy

→ Fertilization.
→ cleavage division.
→ implantation.

I- Fertilization

* Definition:

It is the fusion of the Male & female gametes (union of a sperm & an ovum)

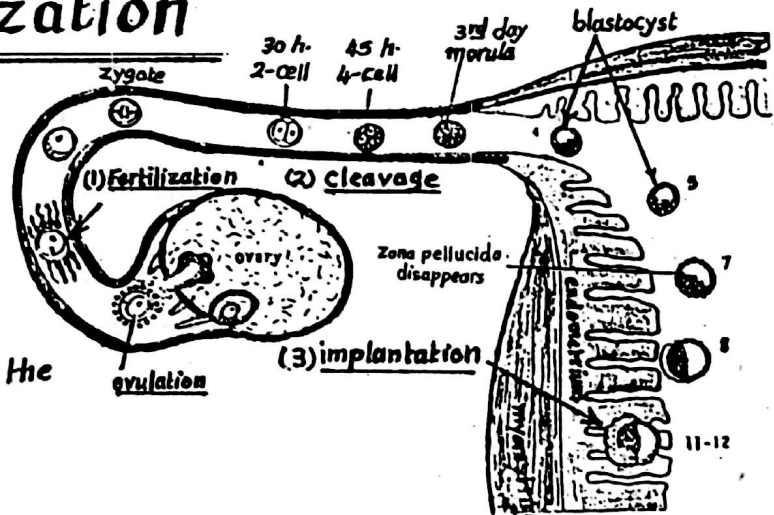
* Site: it occurs in the lat. $\frac{1}{3}$ of the Fallopian tube.

* Mechanism:

(1) Only one sperm (of the 200-300 millions sperm deposited in vagina) is Capable of fertilizing the ovum & is called the fertilizing sperm. The other sperms help the fertilizing sperm by detaching the cells of the Corona radiata by enzymatic action.

(2) The fertilizing sperm pierces the zona pellucida & penetrates the ovum.

(3) A Fertilization membrane is formed around the ovum preventing further Sperm entry.



(4) The head of the penetrating sperm detaches from the rest of the sperm & swells to form the male pronucleus (containing the haploid number of chromosomes).

(5) The nucleus of the ovum forms the female pronucleus (containing the haploid n of chromosomes).

(6) The nuclear membranes of the 2 pronuclei disappear & their chromosomes become around the equator thus the zygote is formed.

* Results of fertilization:

- (1) the diploid number of chromosomes is restored (46 ch.).
- (2) the sex of the embryo is determined (see P. 17).
- (3) Activation of the zygote (structural & chemical changes) occurs.
- (4) Cleavage division (series of mitotic divisions) starts in the zygote.

Cleavage division

***Type:** series of mitotic divisions occurring in the zygote. Each cell resulting from the cleavage is called "blastomere".

***Site:** cleavage divisions occur in the zygote as it passes in the uterine (Fallopian) tube to reach the uterine cavity.

* Steps:

(1) The 2-cell stage: appears about 30 hours after fertilization.

(2) The 4-cell stage: " " 45 " " "

(3) The Morula (12-16 cell stage) appears about the 3rd day
* it is still surrounded by zona pellucida.

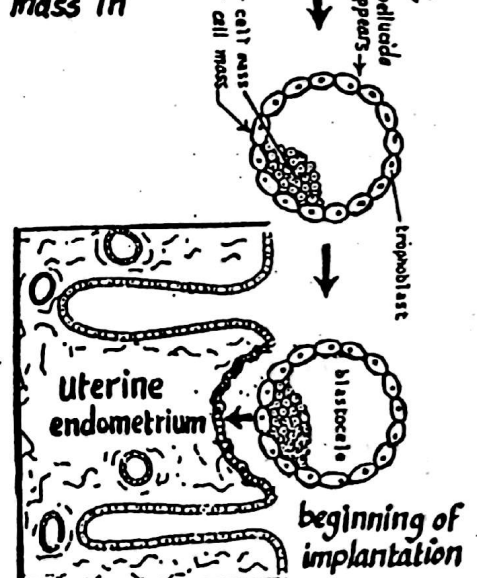
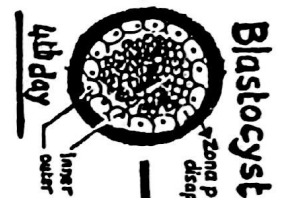
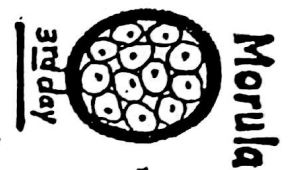
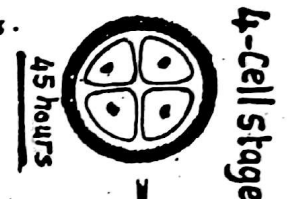
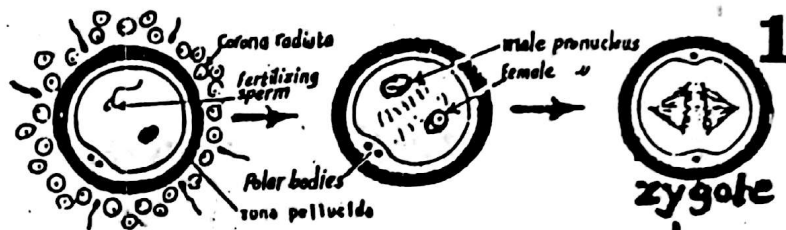
* Its cells become soon arranged into an inner cell mass in the center & outer cell mass in the periphery.

(4) The Blastocyst: (develops in the 4th day)

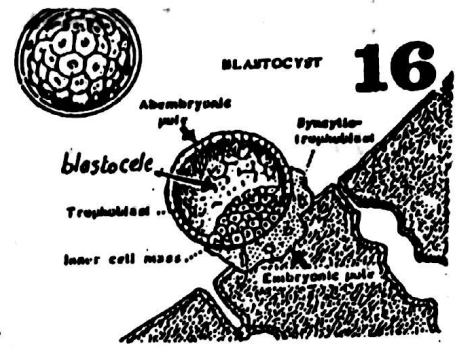
* as the cells of the morula continue to divide, fluid from the uterine cavity enters the spaces between the cells.

* these spaces join each other forming one large cavity called blastocoel & the morula is now called blastocyst.

* zona pellucida disappears by the end of the 4th day.



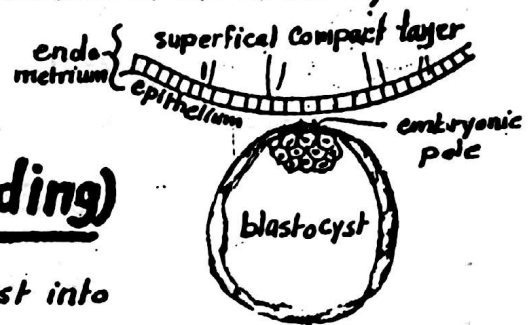
* the blastocyst reaches the uterine cavity by the 5th day.



* Differentiation of the blastocyst:

- the cells of the outer cell mass (the outer shell) form the trophoblast (will form foetal membranes).
- the cells of the inner cell mass become located at one pole & called the embryo blast (will form the embryo itself).
- the pole of the blastocyst at the embryoplast is called the embryonic pole
- the opposite pole is called the abembryonic pole.

* The blastocyst becomes attached to the endometrium of the uterus by the 5th or 6th day after fertilization.



Implantation (embedding)

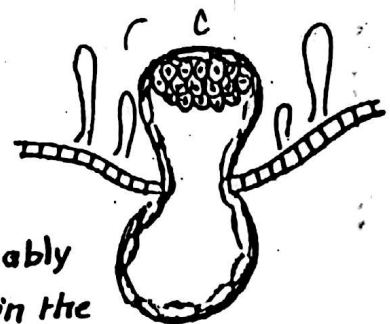
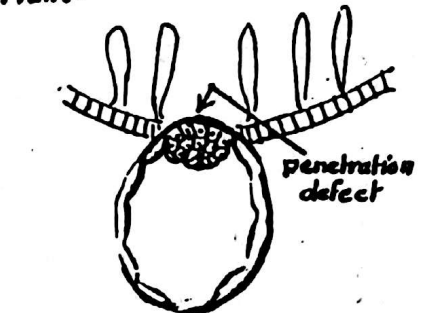
* Definition: It is the penetration of the blastocyst into the superficial compact layer of the uterine endometrium.

* Time: begins about the 6th or 7th day & is complete about the 11th or 12th day after fertilization.

* Normal site of implantation: the endometrium of the post. wall of the fundus of the uterus.

* Steps:

- (1) The blastocyst becomes attached to the endometrium by its embryonic pole.
- (2) The trophoblast cells on the embryonic pole begin to erode the epithelium of the endometrium (probably by enzymatic action) forming a penetration defect in the endometrium.
- (3) The blastocyst enters the endometrium (by its embryonic pole) through the defect to become embedded into it.
- (4) After complete embedding of the blastocyst, the penetration defect is closed by fibrin clot. Implantation is completed by the growth of the epithelium to cover the defect.



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BLASTOCYST

16

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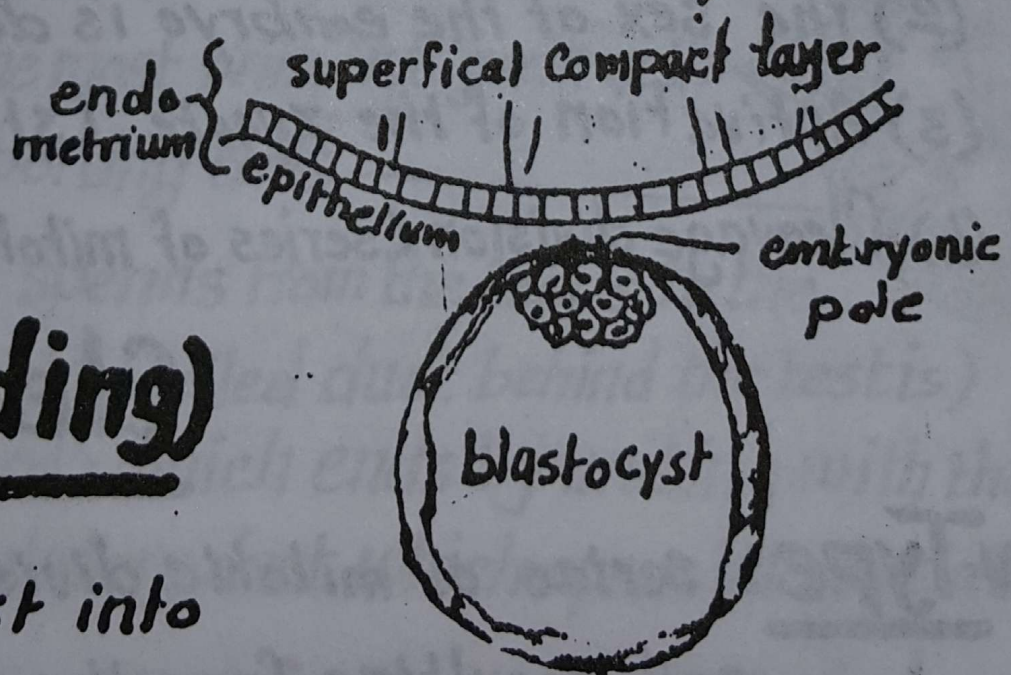
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the endometrium of the uterus by the



embedding)

blastocyst into

uterine endometrium.

* Abnormal Site of implantation:

(A) Outside the Uterus (Ectopic pregnancy)

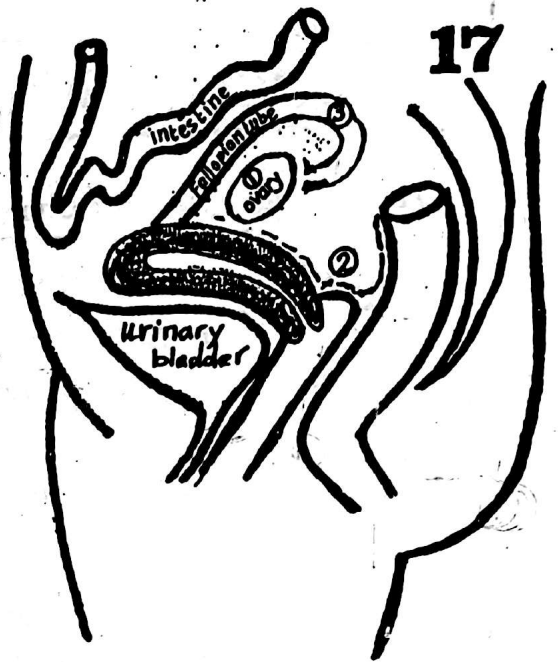
- (1) Ovarian pregnancy : implantation in the ovary
- (2) Abdominal : implantation may occur in the peritoneum of the pelvis, intestine or omentum.

N.B the 2 previous types are rare.

- (3) Tubal pregnancy : implantation in the fallopian tube $\rightarrow$ swelling $\rightarrow$ rupture usually occurs in the 2nd month causing internal haemorrhage.

N.B : ectopic pregnancy usually ends in death of the embryo.

(B) Abnormal site of implantation inside the Uterus : Placenta Previa : (see placenta p.41).



Sex determination

- * The sex of the embryo is determined at the moment of fertilization
- * The ovum contains the haploid number of chromosomes i.e 23 (22 autosomes + one X chromosome).
- * The sperm also contains the haploid number of chromosomes i.e 23, however, $\frac{1}{2}$ the number of the sperms contain 22 autosomes + Y sex chromosome. The other $\frac{1}{2}$ of sperms contain 22 " + X sex chromosome (see spermatogenesis in Page 2)
- * On fertilization a sperm fuses with an ovum & the diploid number of chromosomes (46) is restored.
- * The Sex of the embryo (whether male or female) is determined as follows:

- (1) If a sperm containing y chromosome fertilizes.

the ovum the result will be a male embryo $\rightarrow$ $\begin{matrix} \text{Y} & \text{X} \\ \text{---} & \text{---} \end{matrix} \rightarrow \begin{pmatrix} 44 \\ + \\ XY \end{pmatrix} \text{ male}$

- (2) If a sperm containing x chromosome fertilizes the ovum, the embryo will be a female embryo $\rightarrow$ $\begin{matrix} \text{X} & \text{X} \\ \text{---} & \text{---} \end{matrix} \rightarrow \begin{pmatrix} 44 \\ + \\ XX \end{pmatrix} \text{ female.}$

Second Week of pregnancy

18

remember number 2 in the 2nd week

The following events (changes) occur during the 2nd week :

- (1) Implantation: the blastocyst completes its implantation by the 11th or 12th day.
- (2) Trophoblast: differentiates into 2 layers
 - syncytio-trophoblast
 - cytotrophoblast
- (3) Embryoblast: (inner cell mass) becomes 2 layers (bilaminar germ disc)
 - formed of
 - Ectodermal layer
 - Endodermal layer
- (4) 2 Cavities are formed
 - Amniotic cavity.
 - Yolk sac.

N.B: during the 2nd week the trophoblast shows a rapid rate of growth as compared to the slow rate of growth of the embryonic disc.

Eighth Day

- (1) Implantation: the blastocyst is partially embedded in the endometrium.

- (2) Inner cell mass (Embryoblast):

* the cells become organized to form a bilaminar germ disc formed of 2 layers.

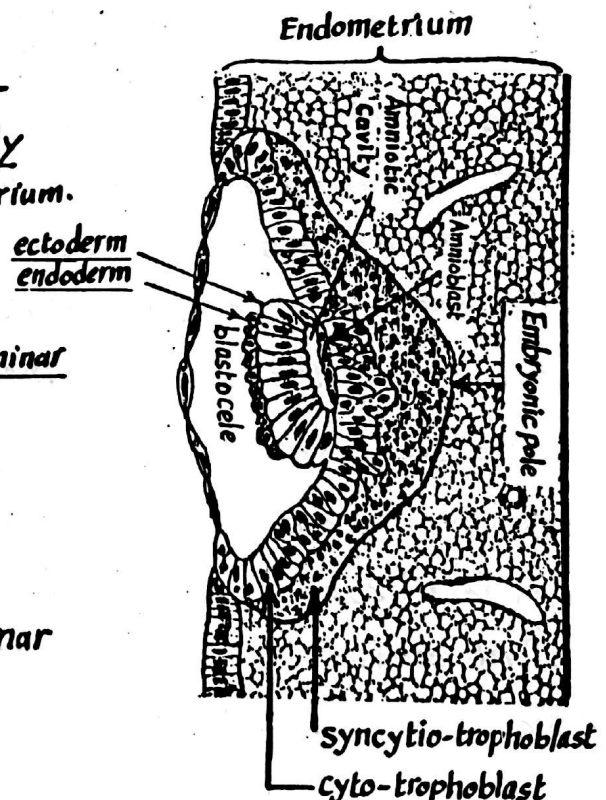
- (a) inner endodermal layer formed of small, polygonal cells facing the lumen.

- (b) Outer ectodermal layer made of tall columnar cells.

- (3) Trophoblast:

- (A) the part of the trophoblast lying over the embryonic pole becomes differentiated into 2 layers :

- (1) Outer dark zone without cell boundaries called syncytio-trophoblast.
- (2) inner pale zone with clear cell boundaries called cyto-trophoblast.



(4) Cavities: the Amniotic Cavity Starts to be formed as follows: **19**

- * small clefts begin to appear between the ectodermal cells & the trophoblast
- * the clefts join each other forming the amniotic cavity.
- * the cytotrophoblast develops a layer of flat cells called the amnioblasts which forms the roof of the amniotic cavity while its floor is formed by the ectodermal layer.

Ninth & Tenth Days (9th & 10th)

(I) Implantation:

- * the blastocyst becomes larger & more deeply implanted.
- * the penetration defect becomes closed by a fibrin clot.

(II) Inner cell mass (embryoblast):

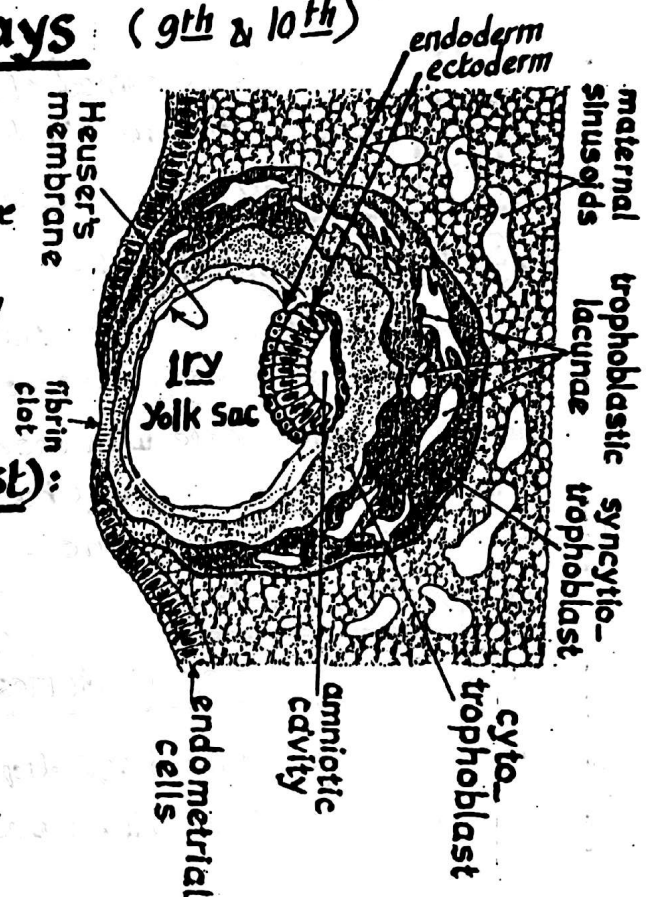
no marked changes from the 8th day.

(III) Trophoblast:

- (1) the whole trophoblast becomes differentiated into Cyto- & Syncytiotrophoblast.
- (2) Spaces called lacunae appear in the syncytiotrophoblast at the embryonic pole.

(IV) Cavities:

- (1) The amniotic cavity becomes larger
- (2) The 1st yolk sac: starts to be formed on the ventral aspect of the embryonic disc as follows:
 - (a) Cells from the endodermal layer grow down to line the inner surface of the cytotrophoblast forming a membrane called Heuser's membrane
 - (b) the 1st yolk sac replaces the cavity of the blastocyst. Its roof is formed by the endodermal layer while the remaining part of its wall is formed by Heuser's membrane.



The 11th & 12th Days

20

I-Implantation:

- * the blastocyst is completely embedded
- * the endometrial epithelium grows to cover the penetration defect.

II-Embryoblast: no marked changes. from the 8th day.

III-Trophoblast: shows marked progress:

(A) Syncytio-trophoblast:

- (1) new lacunae are formed (they are absent opposite the ab-embryonic pole.
- (2) Lacunae communicate with each other forming larger spaces giving the syncytiotrophoblast a trabecular appearance.

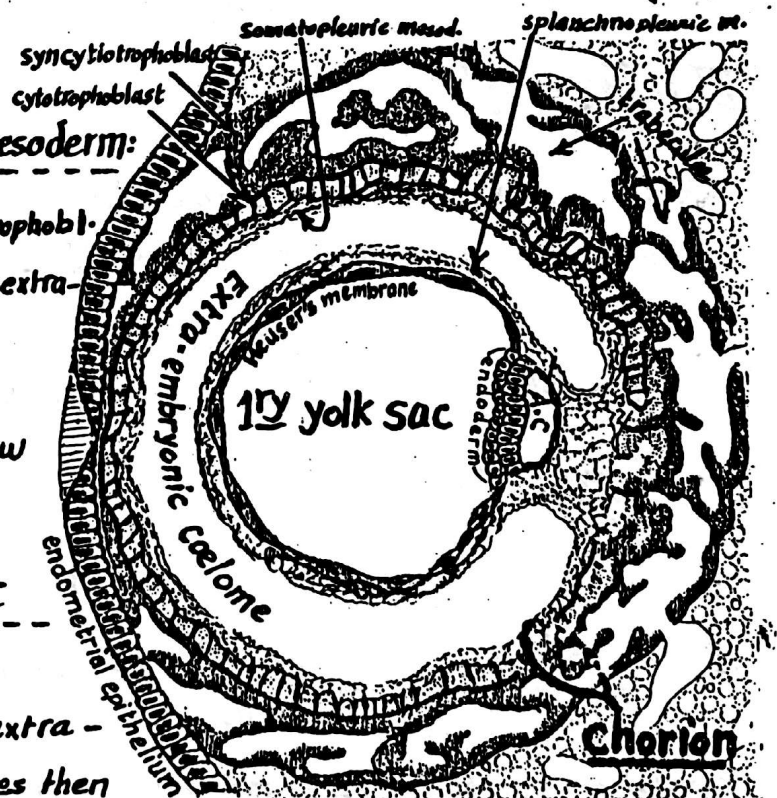
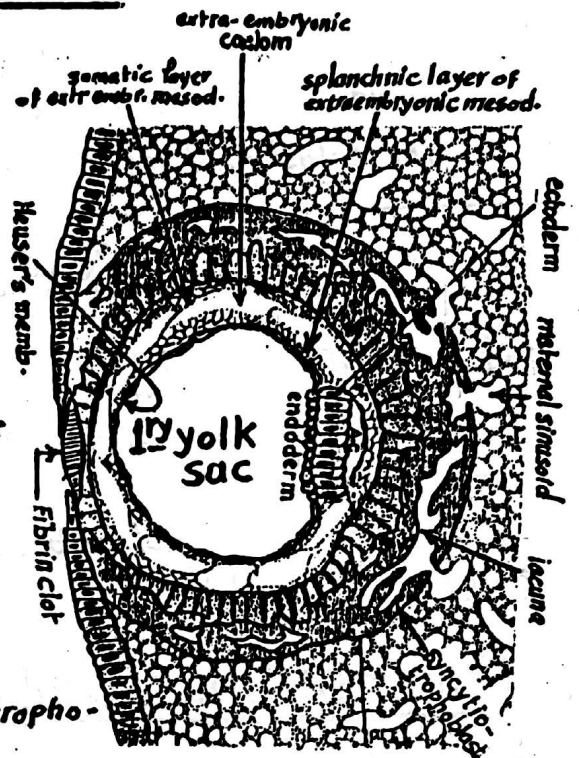
B-Cytotrophoblast:

(1) Formation of extraembryonic mesoderm:

- * Cells of the inner surface of cyto-trophoblast form a very loose tissue called the extra-embryonic mesoderm.
- * the trophoblast will be called the chorion & the blastocyst is now called the chorionic vesicle.

(2) Formation of extra-embryonic Coelom:

- * Cavities are formed inside the extra-embryonic mesoderm. These cavities then fuse together forming the extra embryonic Coelom.
- * This Coelom divides incompletely the mesoderm into
 - (1) Somato pleuric mesoderm: which lines the cyto-trophoblast & covers the A.C.
 - (2) splanchnopleuric : which covers the yolk sac.



Chorionic Vesicle

N.B the Connecting stalk or body stalk is a mass of mesoderm connecting the roof of the amniotic cavity with the trophoblast.

21

IV- Cavities:

- (1) The amniotic cavity becomes larger.
- (2) The Yolk sac shows no definite changes.
- (3) The extra embryonic Coelom develops (see P.20).

13th Day

I- Implantation:

is complete with closure of the penetration defect by epithelium.

II- Embryoblast:

no marked changes from the 8th day.

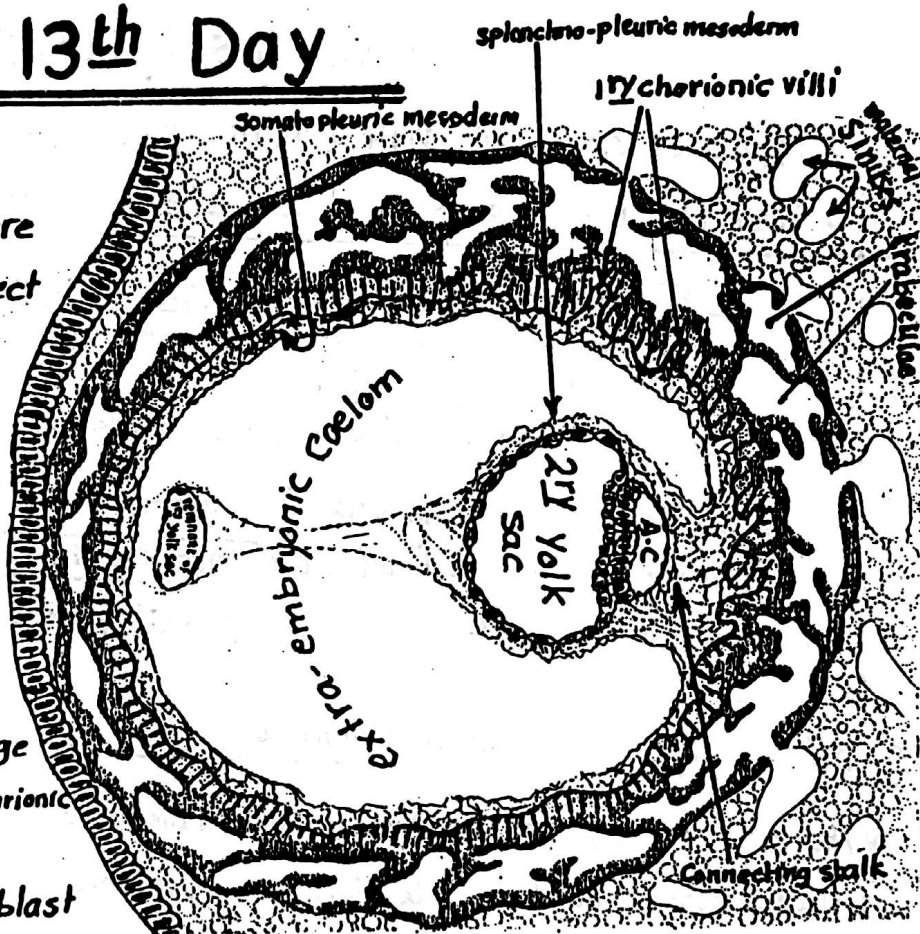
III- Trophoblast:

the most prominent change is the appearance of 1^{ry} chorionic villi as follows:

parts of the cyto-trophoblast at the embryonic pole project into the syncytio-trophoblast forming the 1^{ry} chorionic villi which are surrounded by trophoblastic lacunae.

IV- Cavities:

- (1) Amniotic cavity shows no major change.
- (2) Formation of the Secondary yolk sac: the largest part of the 1^{ry} yolk sac is cut-off & the remaining part becomes the 2^{ry} yolk sac.



(A) Changes in the Embryonic disc:

- (1) Formation of intra-embryonic mesoderm leading to the transformation of the bilaminar germ disc into a trilaminar disc.
- (2) Formation of the notochord which is a temporary supporting element to the embryonic disc.

(B) Changes in the trophoblast (Chorion):

3 types of chorionic villi (Primary, Secondary & tertiary) are formed & cover the whole surface of the chorionic vesicle.

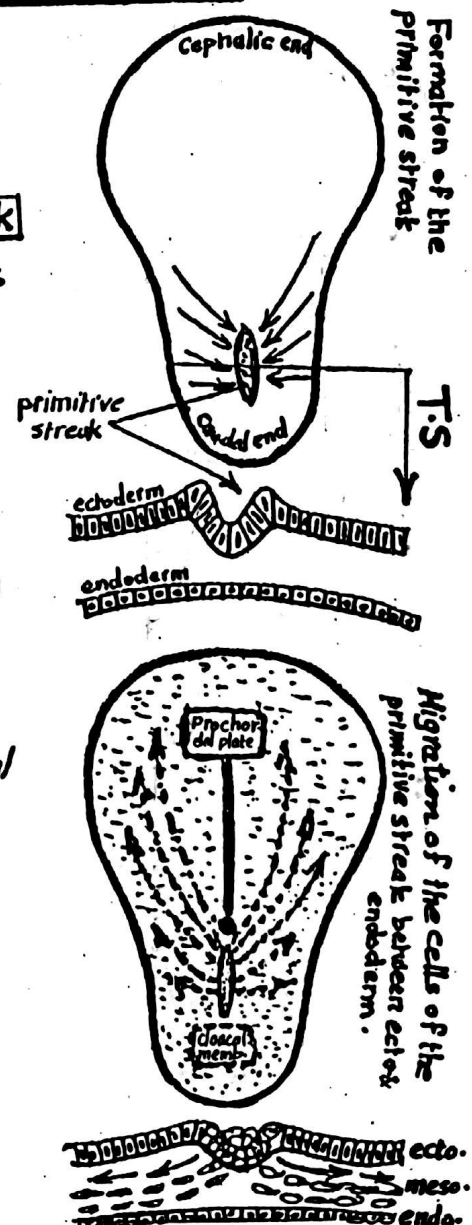
I- Formation of intraembryonic mesoderm

A- Formation of the primitive streak:

At the beginning of the 3rd week, the ectodermal cells in the caudal part of the bilaminar germ disc migrate to the middle line forming the **primitive streak** (a narrow midline groove having slightly bulging areas on either side)

B- Migration of the cells of the primitive streak:

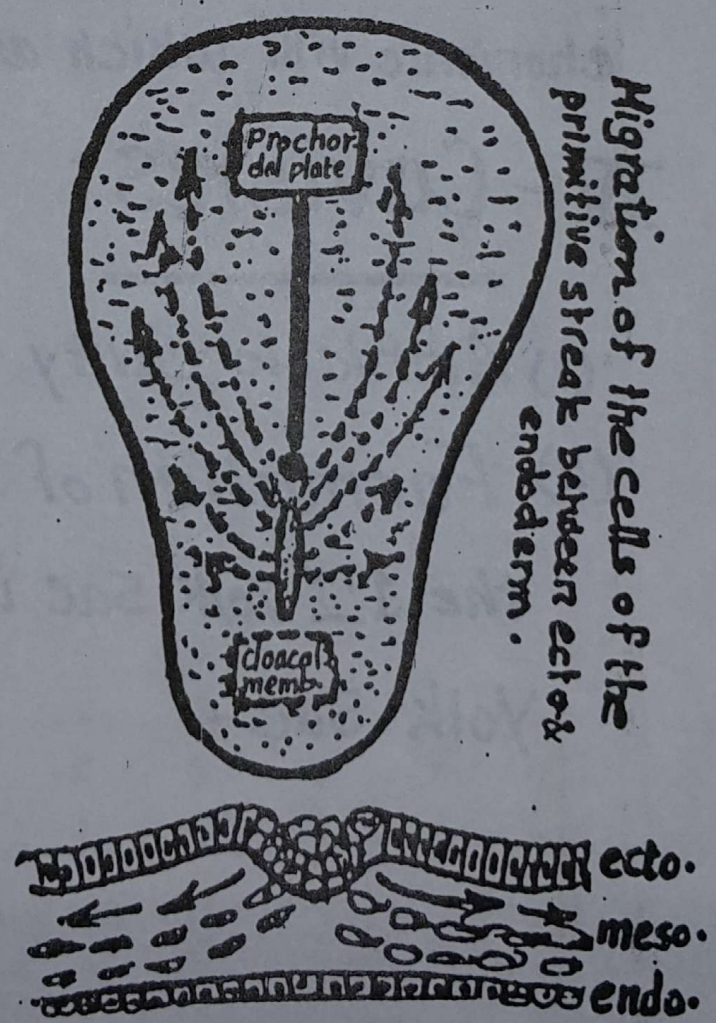
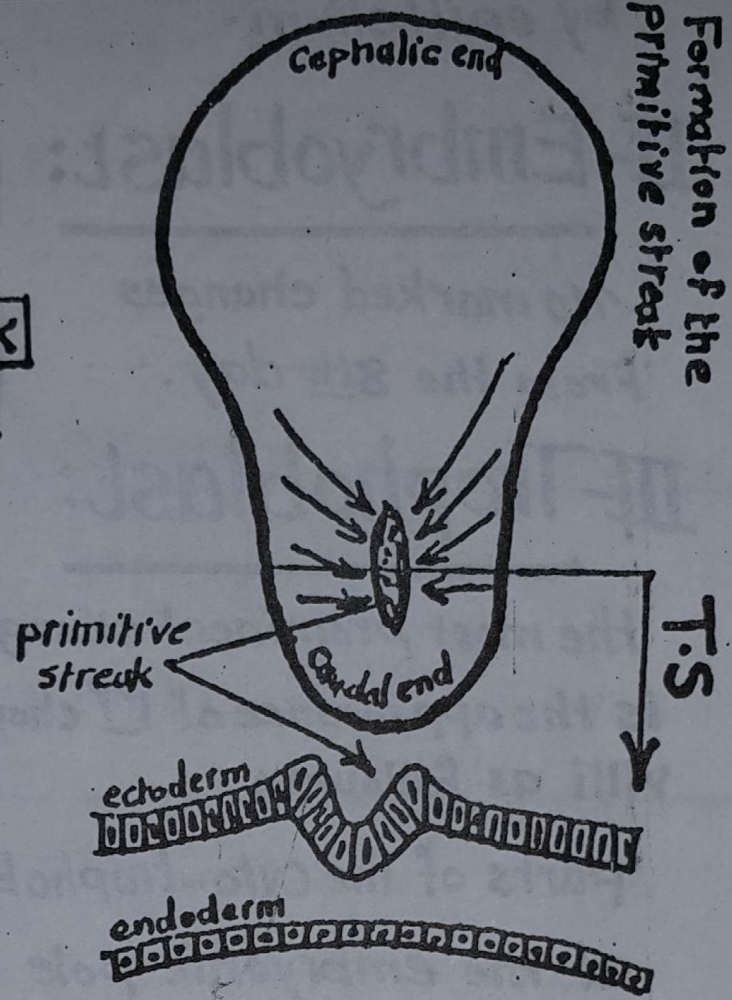
- * the cells of the primitive streak insinuate themselves between ectoderm & endoderm & migrate in all directions
- * the new layer of cells formed between the endoderm & ectoderm is called intra embryonic mesoderm.
- * the migration of the mesodermal cells anteriorly occurs on the sides of the middle line & the prochordal plate.
- * In this way the midline region + the prochordal plate do not contain mesodermal cells & remain bilaminar (containing endoderm & ectoderm only) while the remaining part of the embryonic disc is trilaminar i.e. formed of ecto, endo & mesoderm.



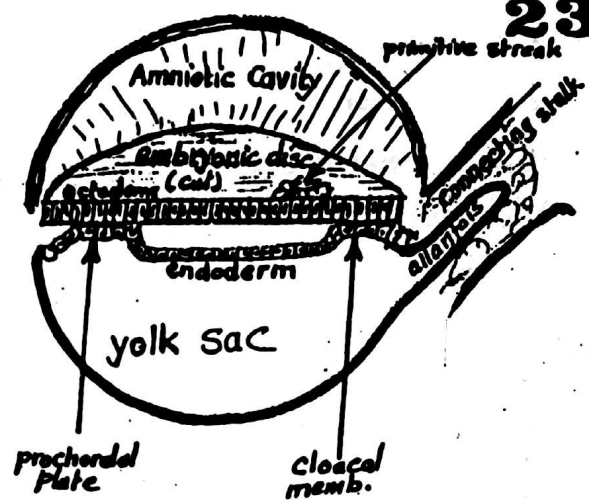
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N.B: 1-Cloacal membrane: in the region immediately behind the caudal end of the primitive streak the embryonic disc remains bilaminar i.e ectoderm & endoderm with no intervening mesoderm. this bilaminar part is called the cloacal membrane.



(2) Prochordal plate: in the cephalic part of the embryonic disc, the ectoderm remains in firm contact with endoderm i.e bilaminar. This bilaminar median part in the cephalic aspect of the embryonic disc is called the prochordal plate which, later on, will become the bucco-pharyngeal membrane.

Formation of the notochord

(1) Formation of primitive node & primitive pit:

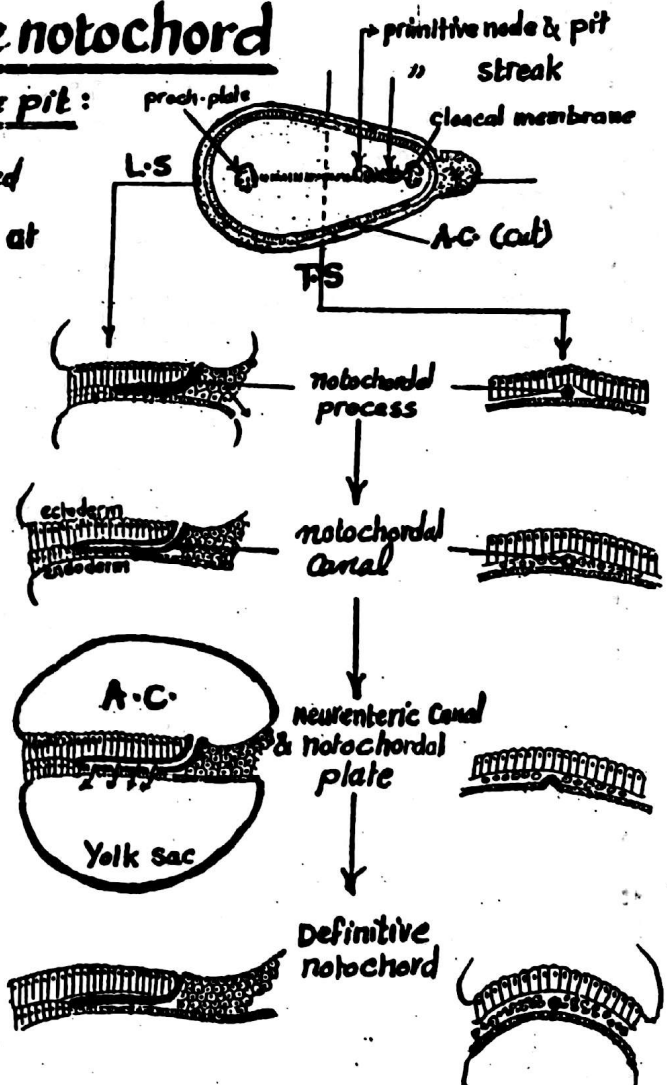
- a marked thickening of the ectoderm called primitive node (Hensen's node) appears at the cephalic end of the primitive streak
- the primitive node consists of a small central depression called the primitive pit surrounded by a slightly elevated area.

(2) Notochordal Process:

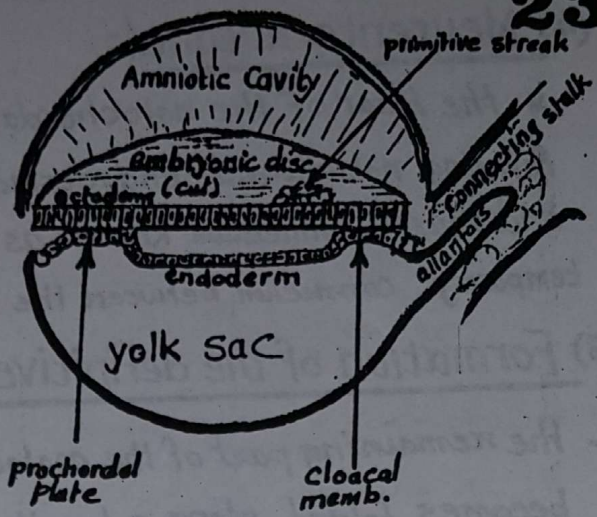
the cells of the primitive node proliferate & form a solid rod of cells called notochordal process (head process) which grows in a cephalic direction along the middle line between the ectoderm & endoderm.

(3) Notochordal Canal: a small central canal is formed inside the notochordal process starting as a forward extension from the primitive pit & passing anteriorly.

The notochordal canal is connected to the amniotic cavity at the primitive pit.



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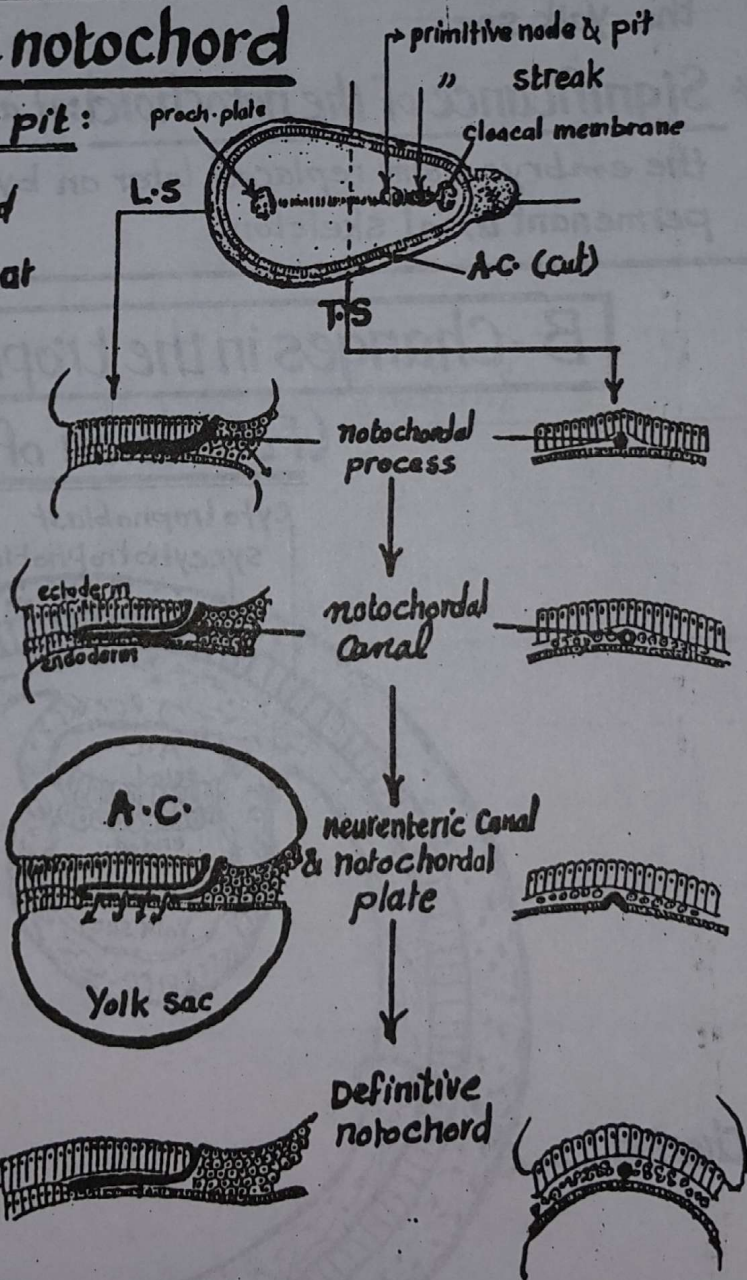
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(4) Neurenteric canal:

* the floor of the notochordal canal fuses with the underlying endoderm forming notochordal-endodermal plate which later breaks down & disappears and thus a connection known as neurenteric canal is formed serving as a temporary connection between the amniotic cavity & yolk sac.

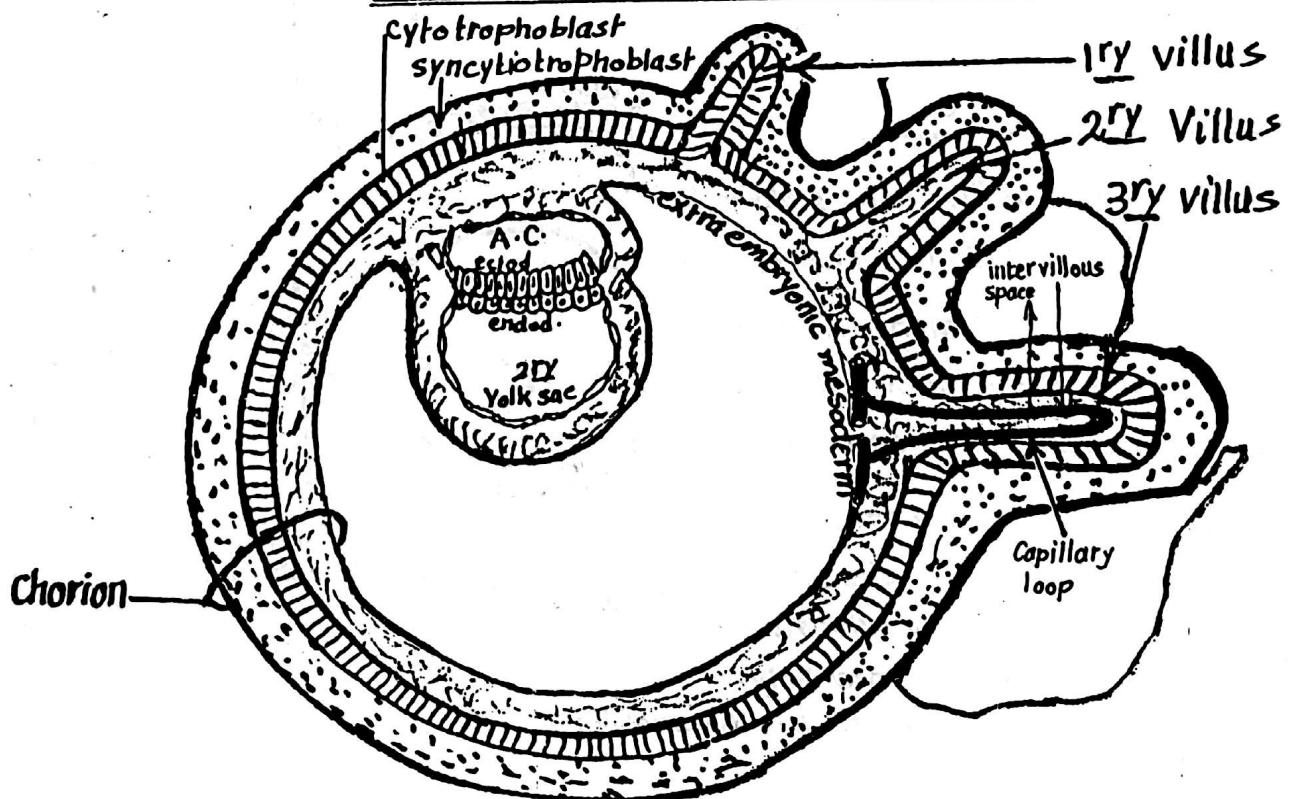
(5) Formation of the definitive notochord:

- the remaining part of the notochord (known as the notochordal plate) becomes folded along a longitudinal axis forming the definitive notochord which is a solid cord of cells present in the middle line between the ectoderm & endoderm.
- the endoderm below the notochord becomes reconstructed to form the roof of the yolk sac.

* Significance of the notochord: it acts as a temporary axial skeleton for the embryo being replaced later on by the vertebral column which is the permanent axial skeleton.

B - Changes in the trophoblast (chorion) in the 3rd week

(Formation of the chorionic villi)

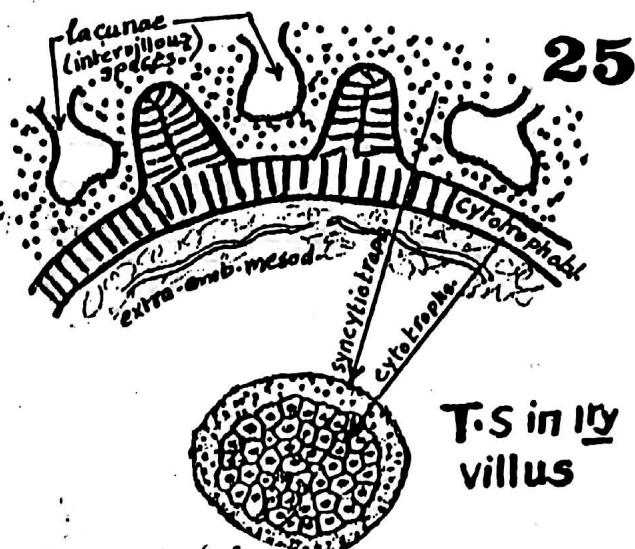


1- Primary Chorionic Villi:

* begin to appear by the end of the 2nd week at the embryonic pole of the chorionic vesicle & increase in number by the beginning of the 3rd week.

* each 1st villus is formed of:

- (1) a central core of cytotrophoblast.
- (2) a covering layer of syncytio trophoblast.

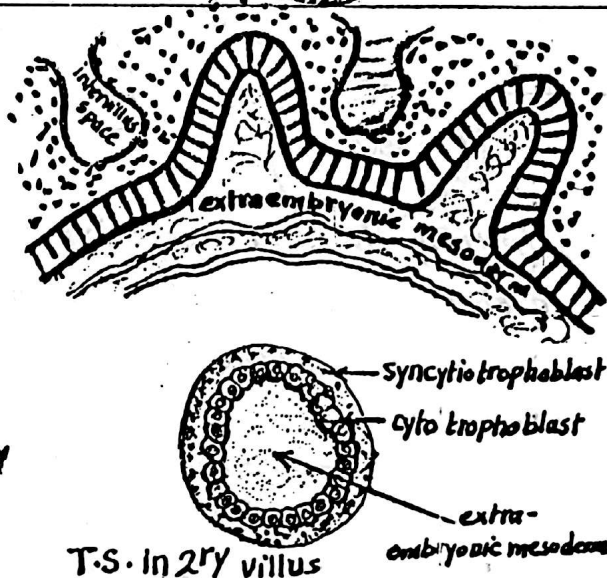


2- Secondary chorionic villi:

* by the beginning of the 3rd week cells from the extraembryonic mesoderm which line the cytotrophoblast start to penetrate the 1st villi to form the 2nd chorionic villi

* each 1st villus consists of:

- (a) a central core of extra embryonic mesoderm
- (b) a middle zone of cyto trophoblast.
- (c) an outer layer of syncytio trophoblast.

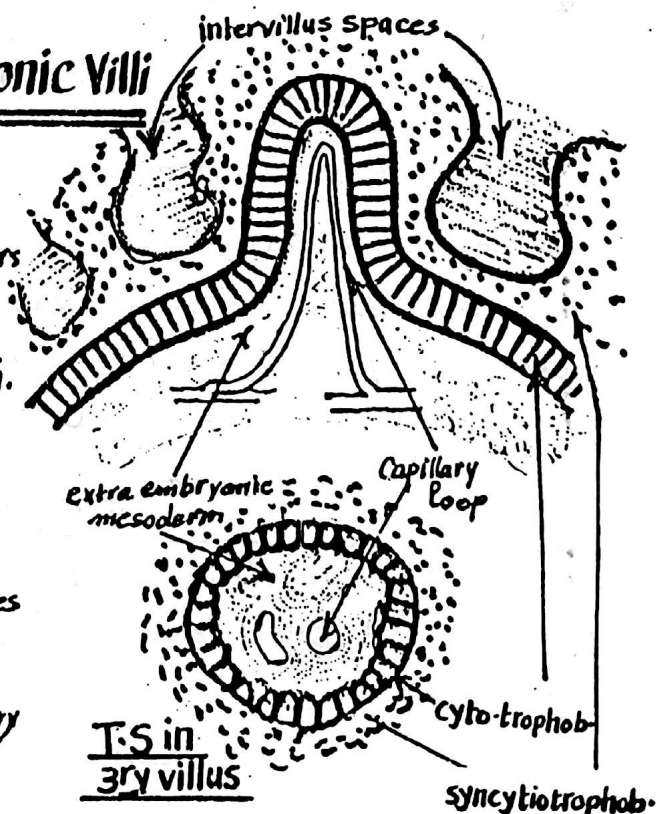


(3) Tertiary (functioning) Chorionic Villi

* By the end of the 3rd week a loop of an afferent & an efferent capillary appears in the mesodermal core of the 2nd villi transforming them into tertiary chorionic villi.

N.B: (1) the afferent capillary loop is connected to the umbilical a. while the efferent one is connected to the umbilical vein.

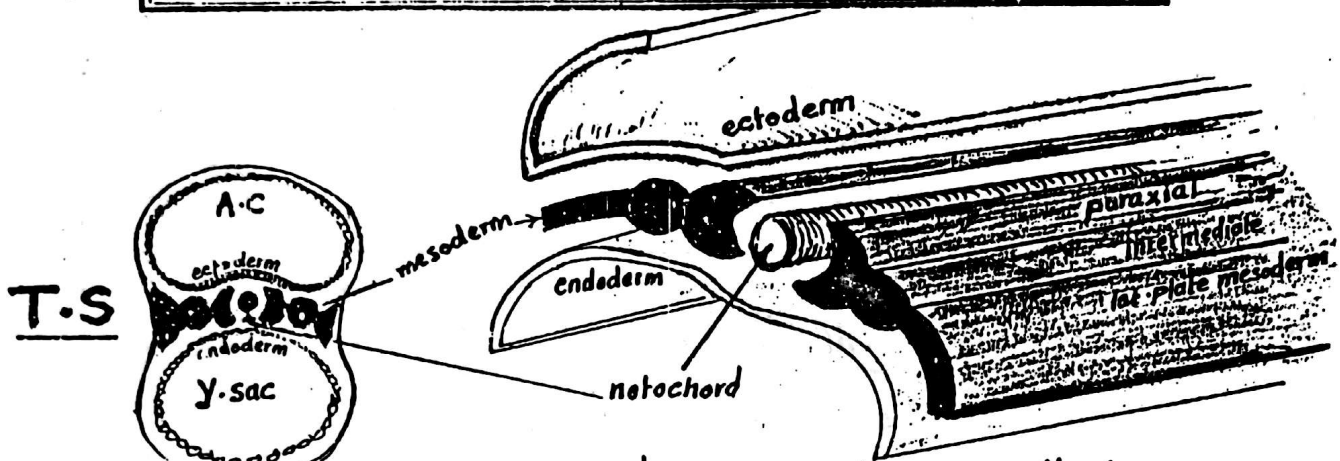
(2) the tertiary villi branch in the Intervillous spaces & oxygen & nutrient substances diffuse from the maternal blood in the intervillous space to the capillary loop in the 3rd villus.



Differentiation of the 3 germ layers during the embryonic period

26

I- **INTRA-EMBRYONIC MESODERM**



(1) Initially the intra embryonic mesoderm is formed by the 17th day as a sheet of loose tissue between the ectoderm & endoderm on either side of the notochord (it is absent in the region of prochordal plate & Cloacal membrane).

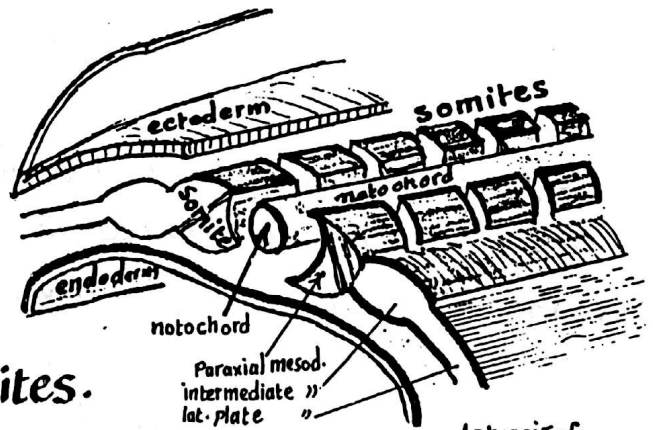
(2) As development proceeds 2 longitudinal grooves appear in the mesoderm on either side of the notochord dividing it into 3 parts :

(a) paraxial mesoderm (b) intermediate mesoderm (c) lat. plate mesoderm

A- **Paraxial mesoderm** :

* Consists of 2 thick longitudinal bands, one on either side of the notochord.

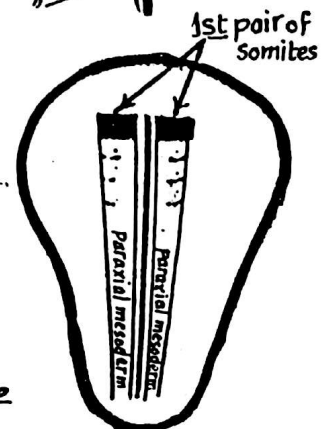
* About the 20th day transverse grooves appear in the paraxial mesoderm dividing it into small mesodermal blocks called **Somites**.



* Rate of formation of the Somites :

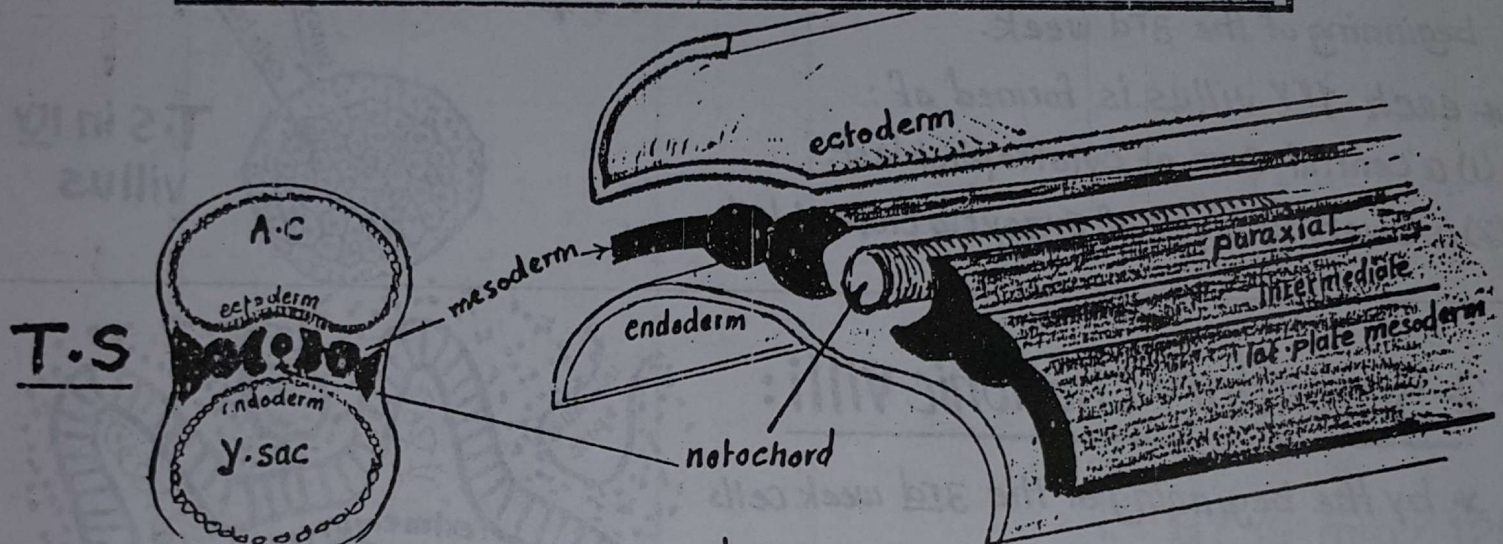
* the paraxial mesoderm begins to divide into somite by the 20th day where the 1st pair (most cephalic) of somites appear.

* 3 additional pairs of somites are formed each day from the 21st to the 30th day i.e by the end of the



during the embryonic period

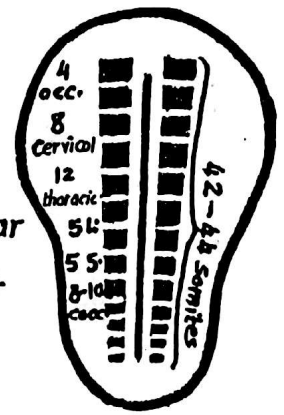
I- INTRA-EMBRYONIC MESODERM



(1) Initially the intra embryonic mesoderm is formed by the 17th day as a

1st month (30 days) about 30 or 31 pairs of somites are formed **27**

* between the 30th & 40th days the rate of formation of somites becomes slower till finally 42-44 pairs of somites are formed.



* Sequence of appearance of the Somites: the somites appear in a cranio caudal direction i.e appear 1st in the cranial part of the paraxial mesoderm then proceed formation caudally.

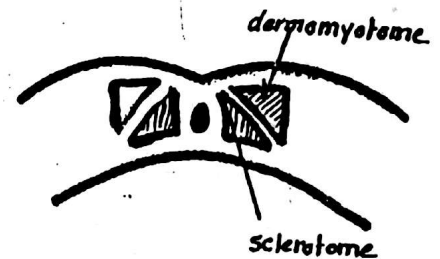
* Number of Somites: 42-44 pairs of somites arranged as follows :
4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral & 8-10 coccygeal

* Fate (differentiation) of the Somites:

* At the end of the 4th week the somites start to differentiate in a cranio-caudal direction

* Each somite divides into 2 parts :

- a ventro-medial part called sclerotome
- a dorso-lateral part called dermomyotome



1- Sclerotome: differentiates into mesenchyme (C.T of the embryo) which will give the C.T, Cartilage cells & bone cells of the axial skeleton

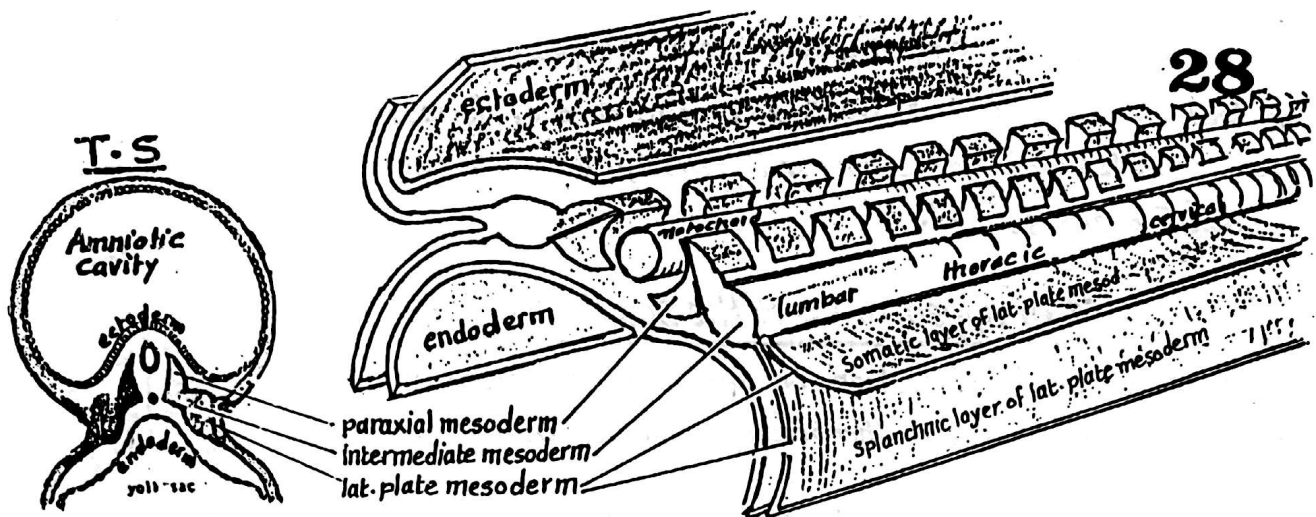
2- Dermomyotome: divides into:

- (a) Lateral part called dermatome which spreads undercover of the ectoderm to form the dermis of skin
- (b) Medial part called myotome: which develops into myoblasts that later will form the skeletal muscles of the body.

* Age determination during the Somite period:

* During the active "Somite period" i.e between 20 & 30 days of development, the age of the embryo can be roughly estimated by counting the number of somites as shown in the following table

Number of somites	1	4	7	10	13	16	19	22	25	28	31
age in days	20	21	22	23	24	25	26	27	28	29	30



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B- Intermediate mesoderm :

* It forms a longitudinal band (one on each side) lying between the paraxial mesoderm (medial to it) & lat. plate mesoderm (lateral to it).

* Fate:

- (1) in the cervical region it becomes segmented.
- (2) In the thoracic region it becomes partially segmented.
- (3) in the lumbar region it is unsegmented forming a solid mass called the nephrogenic cord.

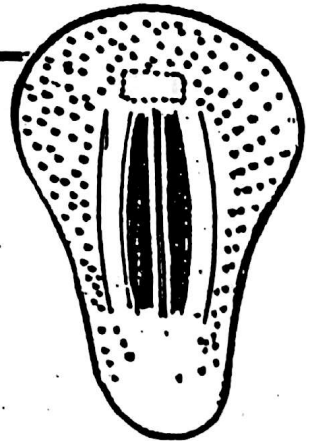
* Derivatives : the intermediate mesoderm will give origin to: (1) the Cortex of the supra-renal gland (2) the excretory units (nephrons) of the kidney (3) the gonads (testis or ovary).

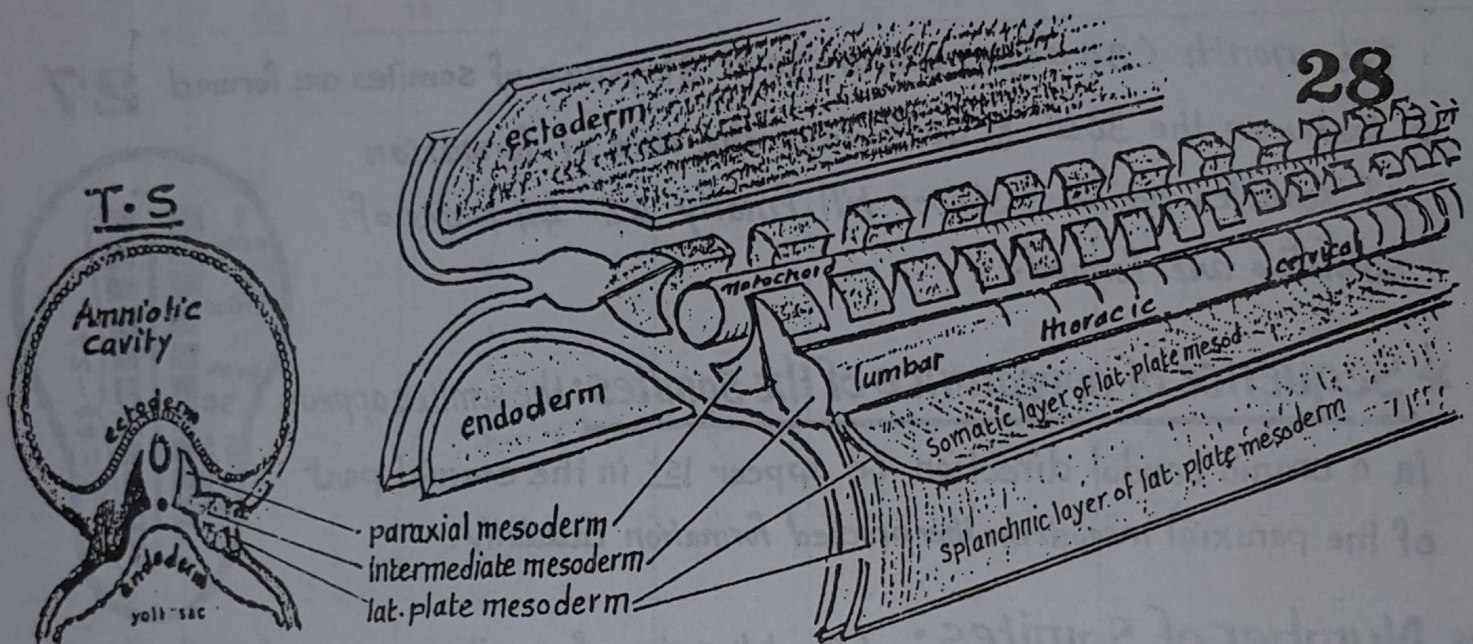
C- Lateral plate mesoderm :

* It lies lat. to the intermediate mesoderm near the edges of the embryonic disc & extends cephalic to the prochordal plate.

* Cavities appear inside the lat. plate mesoderm & unite together forming the intraembryonic Coelom which divides the lat. plate mesoderm into 2 layers :

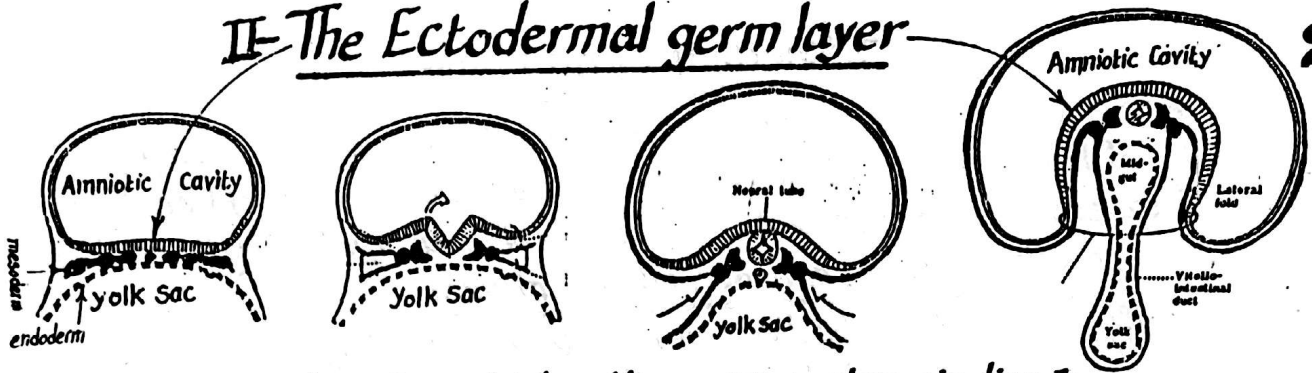
- (1) somatic or parietal layer : which becomes adherent to the ectoderm & forms the muscles, C.T. & supportive elements of the body wall.
- (2) splanchnic or visceral layer : becomes adherent to the endoderm & gives rise to:
 - (a) the serous membranes : pleura, pericardium & peritoneum.
 - (b) the smooth muscles, C.T. of the gastrointestinal & respiratory tracts.
 - (c) the cardio-vascular system.





II- The Ectodermal germ layer

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- (1) At first, the ectoderm forms the dorsal layer of the embryonic disc & constitutes the floor of the amniotic cavity.
- (2) After folding, the ectoderm becomes the outer layer of the body of the embryo
- (3) the ectodermal germ layer differentiates into the following structures:
 - (a) the epidermis of the skin (including the hairs, nails & skin glands).
 - (b) the neural tube which develops to form the nervous system.
 - (c) the sensory epithelium of the sense organs (d) the pituitary gland.

Neural tube

The neural tube develops from the ectoderm in the following steps:

(1) Formation of the neural plate:

at the beginning of the 3rd week, the ectoderm over the notochord is thickened forming a median band called neural plate (neuroectoderm) extending from the primitive node to the buccopharyngeal membrane.

(2) Formation of the neural groove:

the edges of the neural plate become elevated forming Rt. & Lt. neural folds & as a result, the neural plate is transformed into neural groove.

(3) Formation of the neural tube:

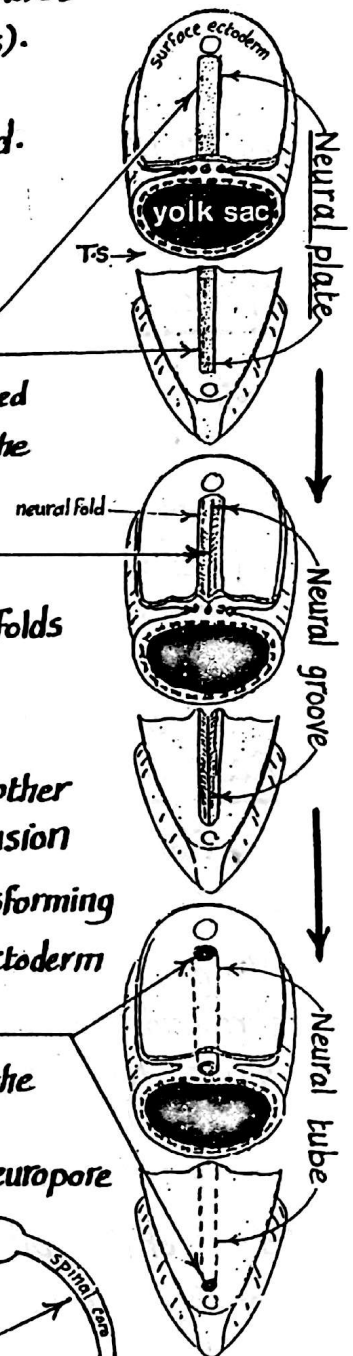
as the neural groove deepens, the Rt. & Lt. neural folds approach each other in the middle line & start fusion at the region of the 4th somite. The fusion of the 2 folds then proceeds in both cranial & caudal direction thus transforming the neural groove into neural tube which is buried under the surface ectoderm.

(4) Closure of the anterior & posterior neuropores:

- at first, the cranial & caudal ends of the canal are open (connected to the amniotic cavity) & called the ant. & post. neuropores.
- then, the ant. neuropore closes at the 20 somite stage while the post. neuropore closes at the 25 somite stage.

(5) Differentiation of the neural tube:

- the broad cranial part of the tube will form the brain
- the narrow caudal part of the tube will form the spinal cord



II- The Endodermal Germ Layer

- * At first, the endoderm forms the ventral layer of the embryonic disc & lines the yolk sac.
- * as a result of folding of the embryonic disc (see below), the upper part of the endodermally lined yolk sac becomes incorporated into the body of the embryo forming the primitive gut which gives the following endodermal derivatives:

- (A) The epithelial lining of : (1) the digestive tract (2) the respiratory tract (which arises as a diverticulum from the primitive gut) (3) the middle ear cavity & Eustachian tube.
(4) most of the urinary bladder and the urethra.
- (B) The parenchyma of : (1) the tonsil (2) thyroid & parathyroid glands (3) thymus gland
(4) liver (5) pancreas.

Folding of the embryonic disc

- * At the time of formation of the somites (by the end of the 3rd week), the flat embryonic disc starts to be folded ventrally & bulges into the amniotic cavity.

- * Types of folds : the embryonic disc becomes folded in 2 directions simultaneously :

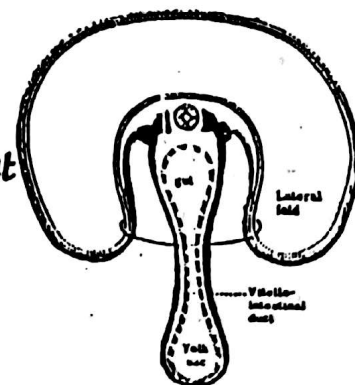
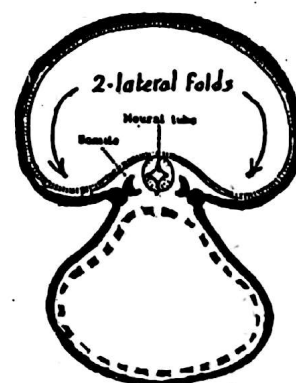
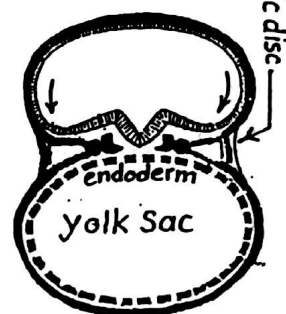
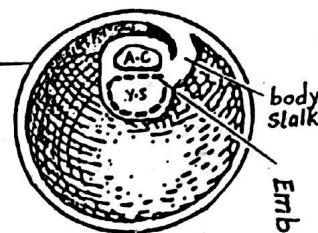
- (1) in cephalo caudal direction : forming the head fold & tail fold.
- (2) in lateral direction : forming 2 lateral folds.

- * Causes of folding :

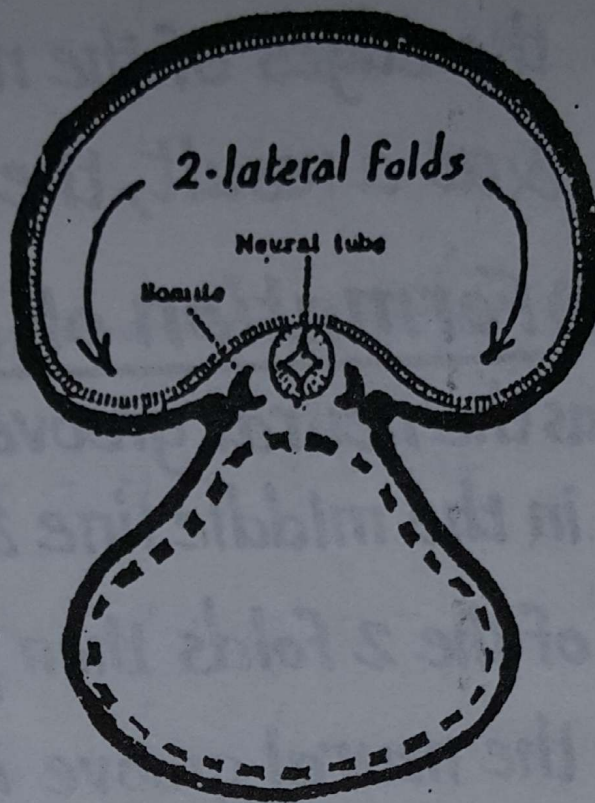
- (1) differential growth in the embryonic disc : the central (axial) area of the embryonic disc grows more rapidly than the peripheral parts
- (2) the progressive expansion of the amniotic cavity.

- * Results of folding :

- (1) the flat embryonic disc becomes cylindrical & the embryo acquires its characteristic form.
- (2) the amniotic cavity which was dorsal to the embryonic disc now surrounds the embryo almost completely
- (3) formation of the gut : as a result of the formation of the the 2 lat. folds, the upper part of the endodermally-lined yolk sac becomes incorporated into the body of the embryo forming the primitive gut
- (4) a part of the yolk sac remains outside the body of the embryo forming the definitive yolk sac which is connected to the primitive gut by the vitello intestinal duct.



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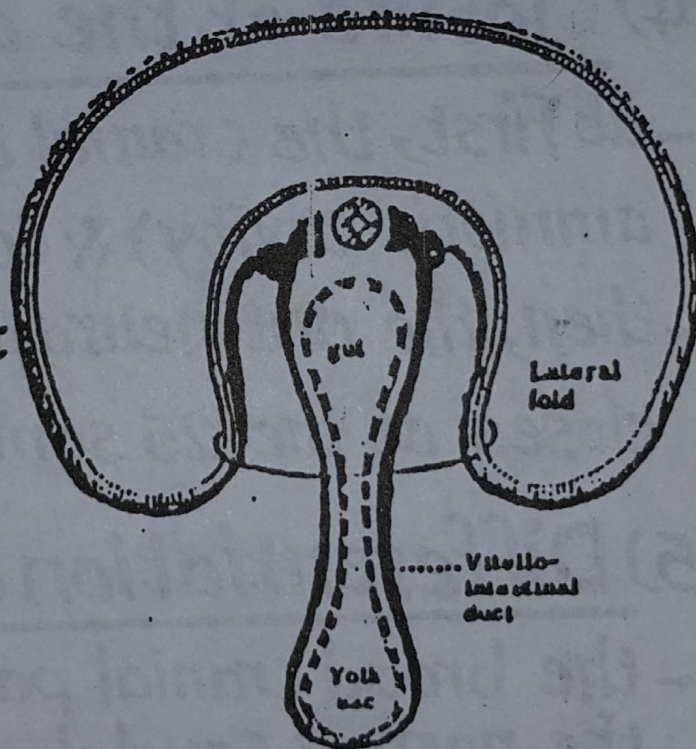
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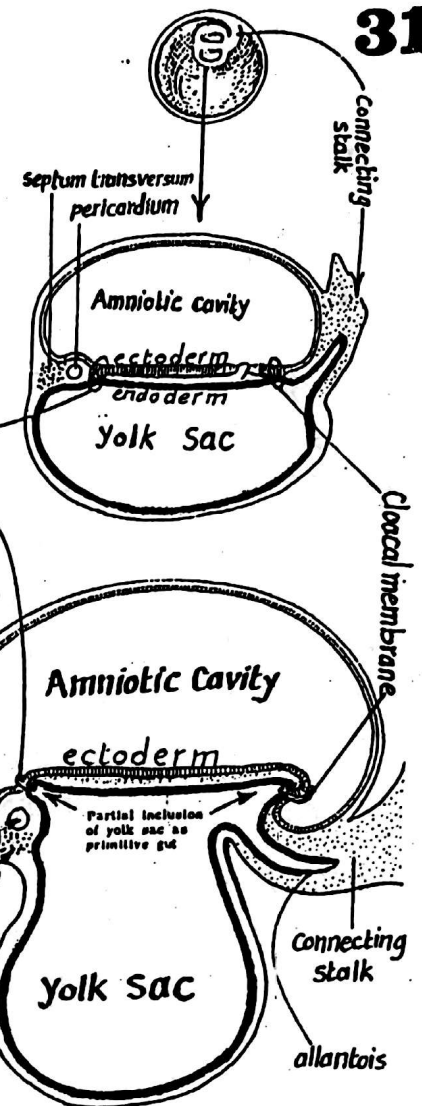


(5) As a result of formation of the head fold & tail fold, the primitive gut becomes divided into 3 parts:

- (a) foregut: the part inside the head fold.
- (b) hindgut: " " " " tail fold.
- (c) midgut: the part between the foregut & the hindgut.

(6) Change of positions of the following structures:

- (a) the buccopharyngeal membrane which was caudal to the pericardial cavity becomes cranial to it after folding.
- (b) the pericardium & heart come to lie on the ventral aspect of the embryo.
- (c) the septum transversum which was cranial to the pericardial cavity becomes caudal to it after folding.
- (e) the connecting stalk which was attached to the caudal end of the embryonic disc comes to lie on the ventral aspect of the embryo.
- (f) the cloacal membrane which was cranial to the connecting stalk comes to occupy the caudal end of the embryo after folding.



(7) Formation of the umbilical ring:

- as a result of folding, the connecting stalk comes to lie on the ventral aspect of the embryo.
- the site of attachment of the connecting stalk to the ventral aspect of the embryo is bounded by the 4 folds & is called the umbilical ring.

* Features of the folded disc:

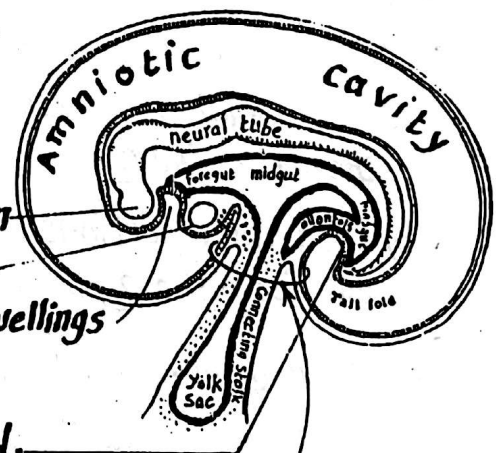
(A) the cranial end shows the following features:

- (1) forebrain swelling: produced by the growing forebrain
- (2) pericardial swelling: produced by the growing heart
- (3) stomodeum: is the depression between the previous 2 swellings

(B) the caudal end shows the following features:

- (1) the cloacal membrane: occupies the most caudal end.
- (2) the allantois & connecting stalk: lie cranial to the cloacal membrane.

(C) the ventral aspect: shows a wide umbilical orifice



& tail fold,

parts:

the hindgut.

features:

caudal

after folding

ventral

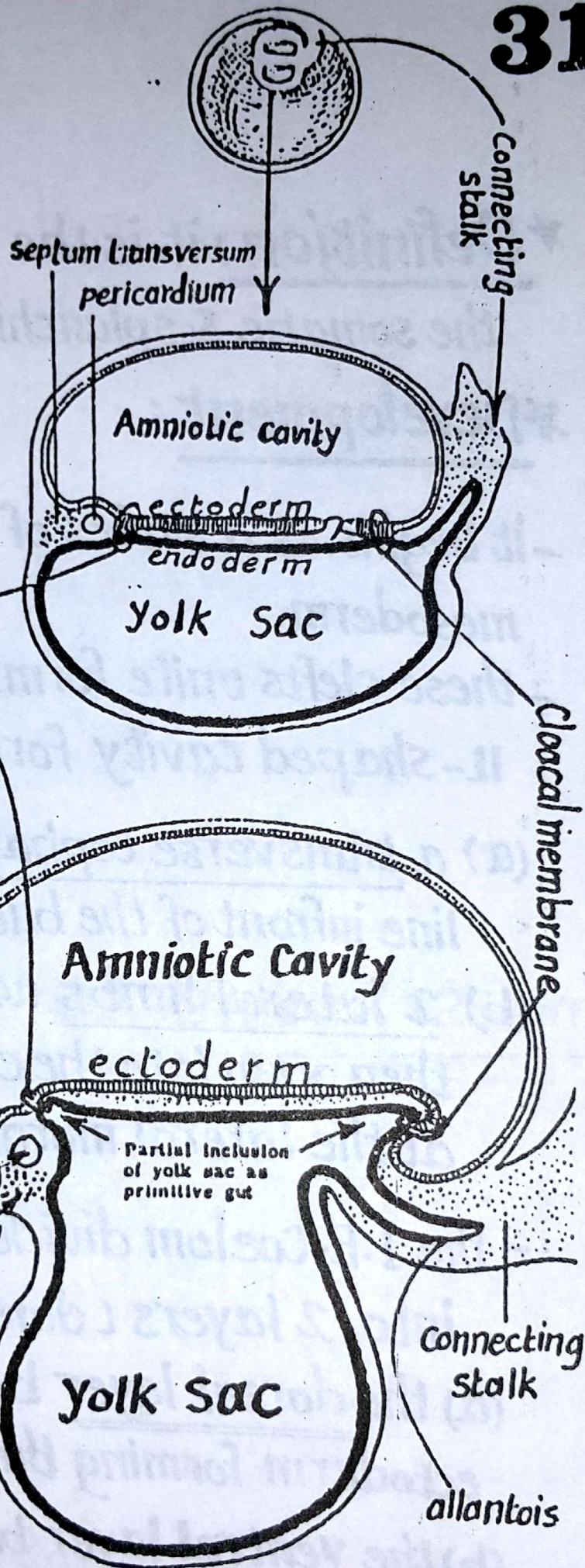
the
folding.

caudal

ventral

connecting

embryo



*** Definition :** it is the body cavity of the embryo which is situated between the somatic & splanchnic layers of the lat. plate mesoderm. It forms the cavities of the trunk.

*** Development :**

- it begins as a series of small clefts in the lat. plate mesoderm
- these clefts unite forming a single continuous U-shaped cavity formed of :

(a) a transverse cephalic part which crosses the middle line in front of the bucco-pharyngeal membran.

(b) 2 lateral limbs which extend caudally then open into the extra-embryonic coelom at the lateral margin of the embryonic disc.

- the I.E. Coelom divides the lat. plate mesoderm into 2 layers (dorsal & ventral):

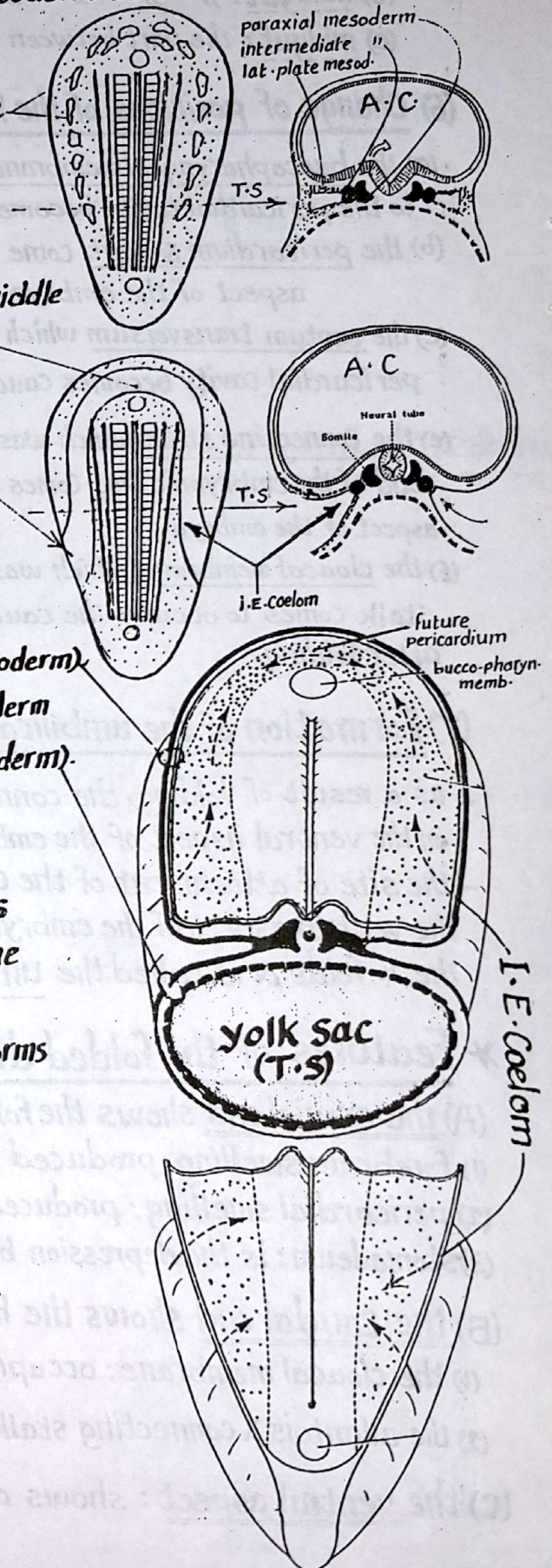
(a) the dorsal layer becomes adherent to the ectoderm forming the somatopleure (ectoderm + mesoderm).

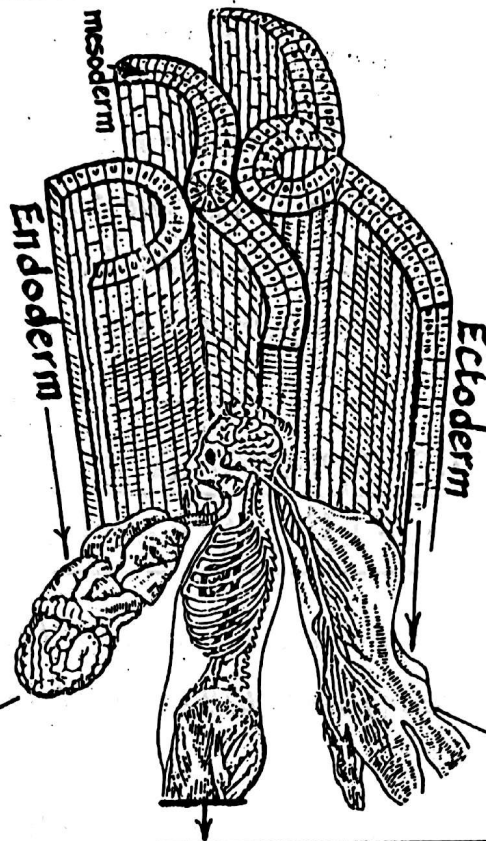
(b) the ventral layer becomes adherent to the endoderm forming the splanchnopleure (endoderm + mesoderm).

*** Differentiation of the I.E. Coelom :**

the I.E. Coelom gives rise to the 3 serous cavities of the body (pericardial cavity, pleural cavities & the peritoneal cavity) as follows :

- the cranial transverse part of the I.E. Coelom forms the pericardial cavity.
- the cranial portions of the 2 lateral limbs will form the 2 pleural cavities.
- the caudal parts of the 2 lat. limbs will unite together forming the peritoneal cavity.



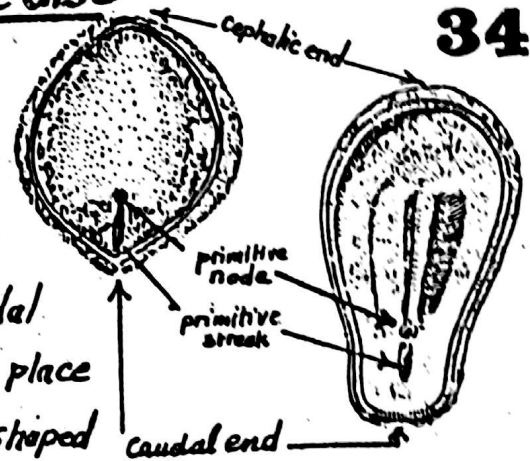


Endoderm	Mesoderm	Ectoderm
I-<u>Epithelial lining</u> of : (1) the <u>alimentary canal</u> except: - ant. part of the mouth - lower part of anal canal (2) the <u>respiratory tract</u> (3) the <u>urinary bladder</u> (except the trigone). (4) most of the <u>urethra</u> (5) <u>Ear</u> : (a) pharyngo tympanic tube. (b) middle ear cavity. (c) inner layer of the eardrum. II-<u>parenchyma</u> of : (1) tonsil (2) thyroid & parathyroid glands (3) Thymus gland. (4) Liver (5) pancreas	(1) All types of connective tissue, Cartilage, bone & joints. (2) All types of muscles : skeletal, smooth & cardiac muscle. (3) All Cardiovascular system : the heart, blood vessels (4) Bone marrow & blood cells (5) lymph vessels & all lymph tissue : lymph nodes & spleen. (6) serous membranes : pleura, pericardium & peritoneum. (7) Dura mater & microglia of the nervous system. (8) Dermis of the skin (9) urogenital system except most of the urinary bladder & urethra. (10) Cortex of the suprarenal gland.	I-<u>Nervous System</u> : - brain & spinal cord - pia & arachnoid mater - sensory epithelium of the sense organs (2) <u>Skin</u> : epidermis, hair & nails (3) <u>glands</u> : pituitary gland & the medulla of suprarenal gland (4) <u>Digestive system</u> : lining of: - ant. part of of oral cavity - lower part of anal canal. (5) <u>Respiratory system</u> : epithelium of the nose. (6) <u>Ear</u> : external auditory meatus & outer layer of ear drum.

Shape of the embryonic disc (in the 1st 3 weeks)

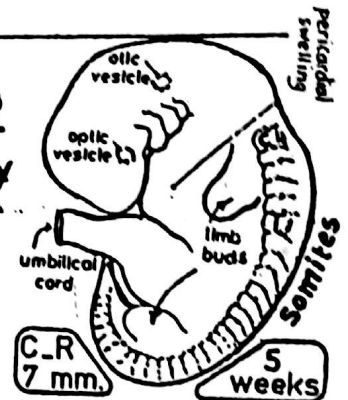
34

- (1) Initially the embryonic disc is rounded or oval in outline.
- (2) As development proceeds, the cephalic part of the disc grows at a higher rate than the caudal part so expansion of the embryonic disc takes place more in its ant. part and it acquires a pear-shaped appearance



External appearance of the embryo during the 4th to 8th week of pregnancy

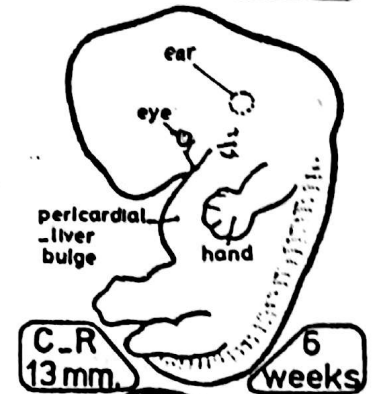
- (1) The forelimb buds appear at the beginning of the 5th week at a level extending from 4th cervical to 1st thoracic somites.



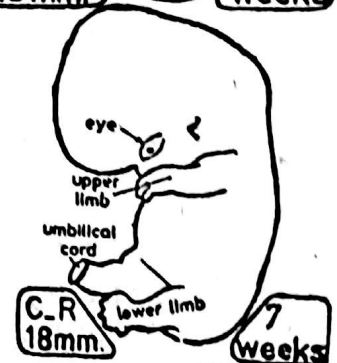
- (2) The hind limb buds appear later & lie at the level of the lumbar & upper sacral somites

N.B : at first the limb buds project at right angle to the long axis of the trunk but in the 7th & 8th weeks :

- a- the upper limb is adducted & rotated laterally.
- b- " lower " is adducted & rotated medially.

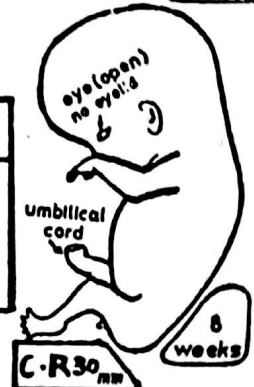


- (3) During this period (4th to 8th week) the face is formed with the appearance of the ears, nose & eyes.



- (4) During the 2nd month, the age of the embryo can be determined by measuring its Crown-rump (C.R) length as follows :

C.R length in mm.	5 - 8 mm.	10 - 14 mm.	17 - 22 mm.	28 - 30 mm
approximate age in weeks	5 weeks	6 weeks	7 weeks	8 weeks



DECIDUA

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* **Definition:** It is the name given to the endometrium after complete implantation of the blastocyst in it. The decidua will be shed away with the fetus at birth.

* **Parts of the decidua:** according to its relation to the chorionic vesicle, the decidua is divided into 3 parts:

(1) **Decidua basalis:** It is the part which lies over the embryonic pole of the chorionic vesicle i.e the part facing the chorion frondosum (see p. 37).

(2) **Decidua Capsularis:** It is the thin layer of decidua which covers the ab-embryonic pole of the chorionic vesicle i.e covering the chorion laeve forming a thin capsule for it.

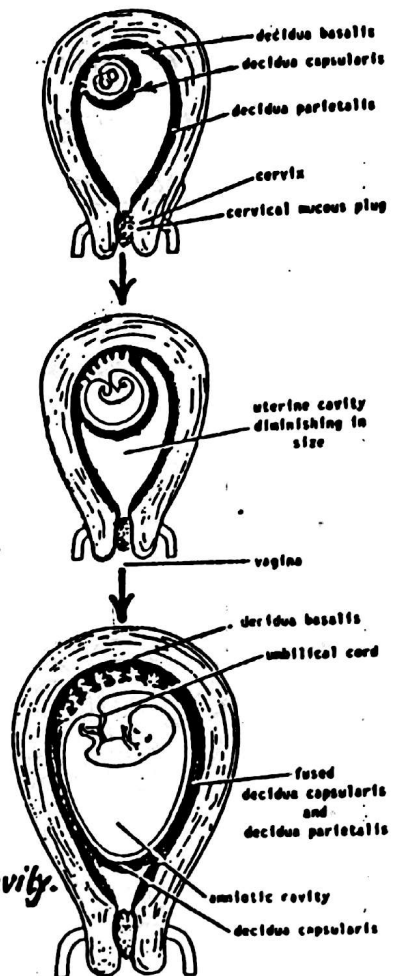
(3) **Decidua parietalis:** is the part lining the rest of uterine cavity.

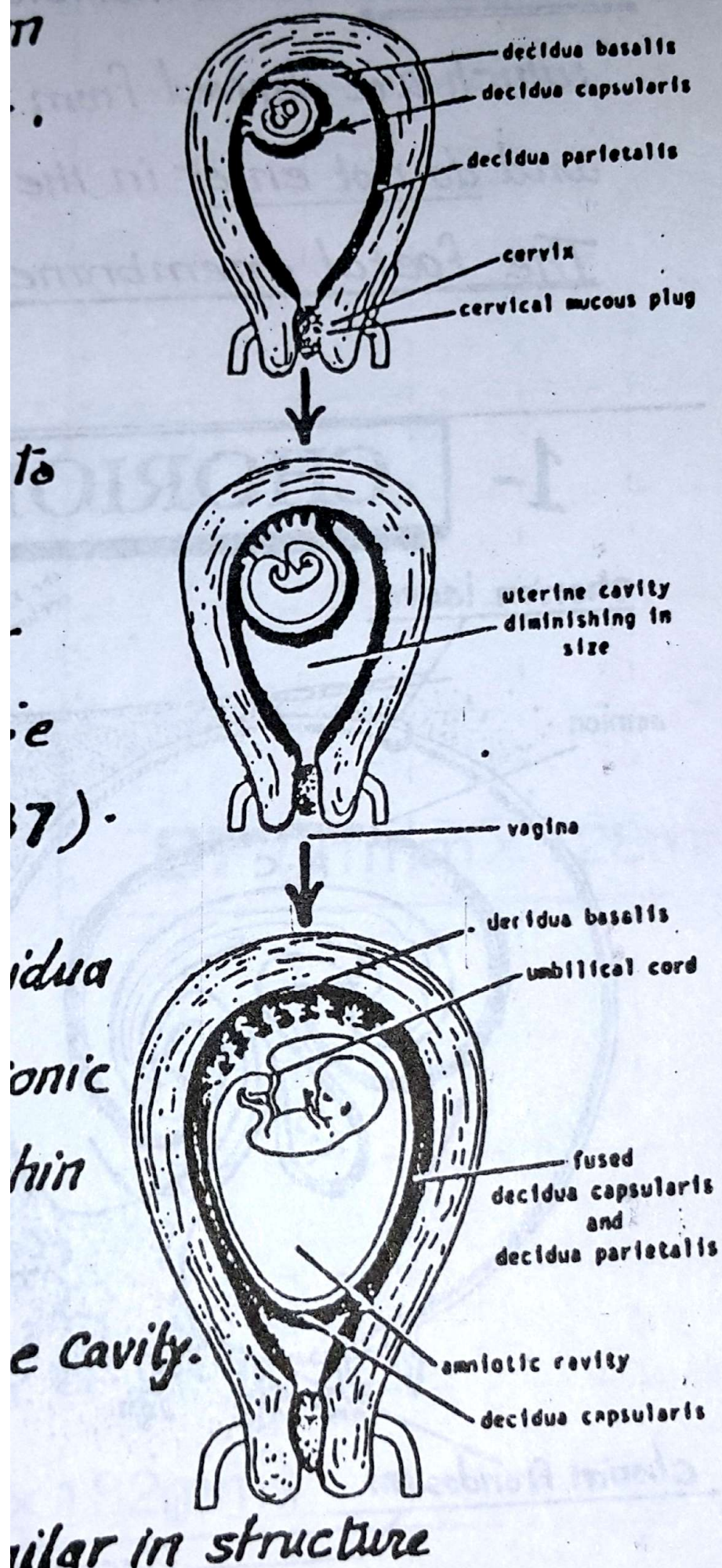
* **Fate of the different parts of the Decidua:**

- * At first the different parts of the decidua are similar in structure
- * As the embryo grows, the decidua basalis develops to form the maternal part of the placenta.
- * The other 2 parts of the decidua (decidua capsularis & decidua parietalis) degenerate while the decidua basalis remains functioning.

* **How does the decidua capsularis & parietalis degenerate?**

- as the embryo grows, the decidua capsularis grows & expands with it and projects into the uterine cavity.
- with further growth of the embryo, the decidua capsularis becomes stretched, begins to degenerate and comes nearer to the decidua parietalis which becomes compressed and begins also to degenerate.
- Finally the decidua capsularis & decidua parietalis come in contact with each other & fuse together obliterating the uterine cavity.





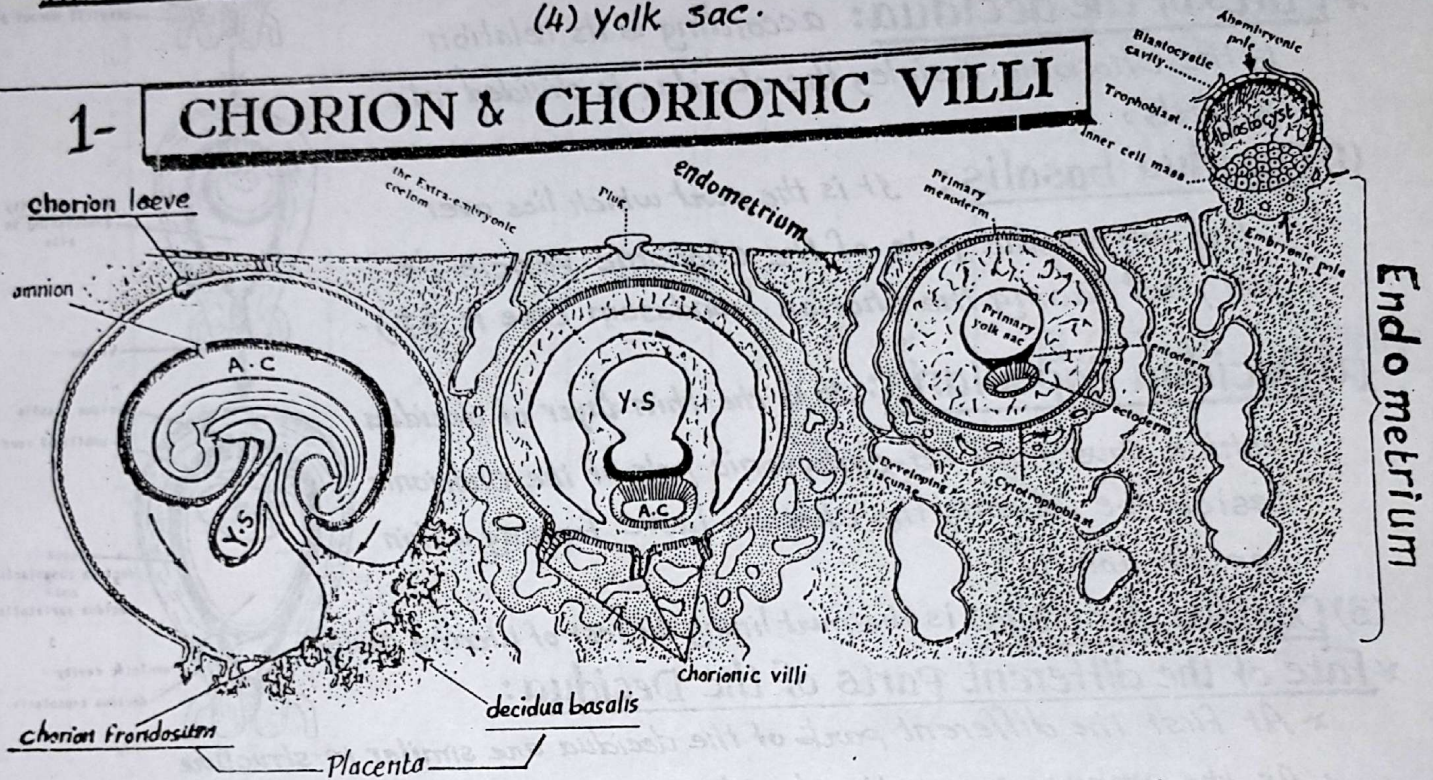
FOETAL MEMBRANES

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*** Definition:** Foetal membranes include all the extra embryonic structures which are derived from the primitive blastomeres (cells of the blastocyst) and do not enter in the formation of the embryo itself.

The foetal membranes are: (1) Chorion (2) Amnion (3) umbilical cord & (4) Yolk sac.

1- CHORION & CHORIONIC VILLI



*** Definition:** Chorion is the name given to the trophoblast after the formation of the extraembryonic mesoderm from its inner surface.

I- Formation of the Chorion:

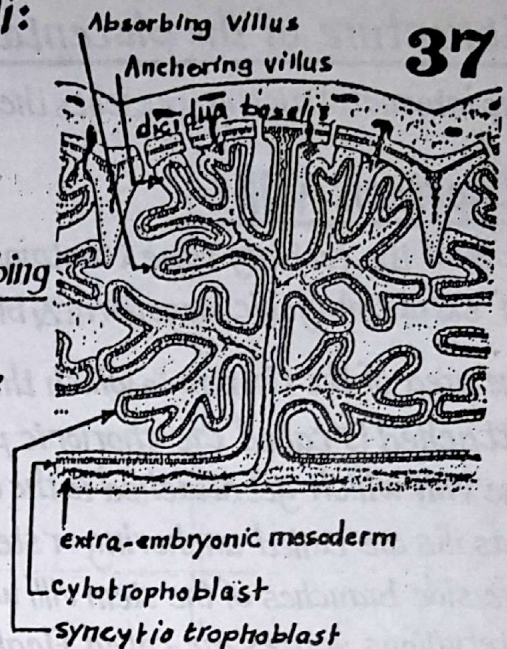
- (1) Before implantation, the wall of the blastocyst is simply called the trophoblast.
- (2) At the beginning of implantation the trophoblast differentiates into an outer syncytiotrophoblast & an inner cytotrophoblast.
- (3) The cytotrophoblast later forms the extra-embryonic mesoderm on its inner surface which later splits into somatopleuric & splanchnopleuric layers.
- (4) Both the trophoblast and the somatopleuric mesoderm are called the Chorion & the blastocyst is called the Chorionic Vesicle.

II Development of the Chorionic villi:

- (1) Primary chorionic villi :
 - (2) Secondary chorionic villi :
 - (3) Tertiary chorionic villi :
- } describe them (see p. 25)

III- Later development of the Chorionic villi:

- * the tertiary villi branch extensively to form a villous tree.
- * the majority of these branching villi are free and surrounded by maternal blood & called absorbing villi.
- * few number of villi penetrate into the substance of the decidua basalis & fix the chorionic vesicle to the wall of the uterus & called Anchoring villi.



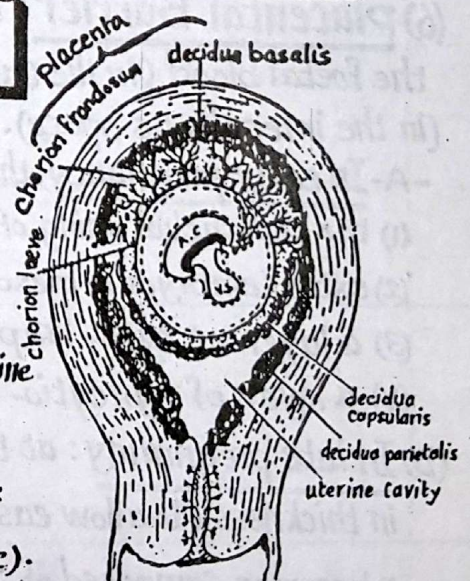
IV- Formation of the 2 parts of the Chorion:

- * In the early weeks of pregnancy the chorionic villi cover the whole surface of the chorionic vesicle.
- * As pregnancy advances the following changes occur :
 - (1) the chorionic villi which lie over the embryonic pole of the chorionic vesicle become more numerous & well developed giving this part of the chorion a leaf-like appearance for this reason this part of chorion is called Chorion frondosum. It is the only functioning part of the chorion.
 - (2) On the other hand, the villi which lie over the remaining part of the chorionic vesicle begin to degenerate by the end of the 3rd month & this part of chorion becomes smooth (having no villi) & is called the Chorion laeve.

PLACENTA

* Definition : It is a vital organ of connection between the foetus & mother allowing physiological exchanges between the foetal & maternal circulations. It acts as a nutritive, respiratory, excretory & endocrine organ for the foetus during the intra-uterine life.

- * Parts : the placenta is formed of the following 2 parts:
 - (1) foetal part : the chorion frondosum (see above).
 - (2) maternal part : the decidua basalis (see page 31).



* Structure of the placenta :

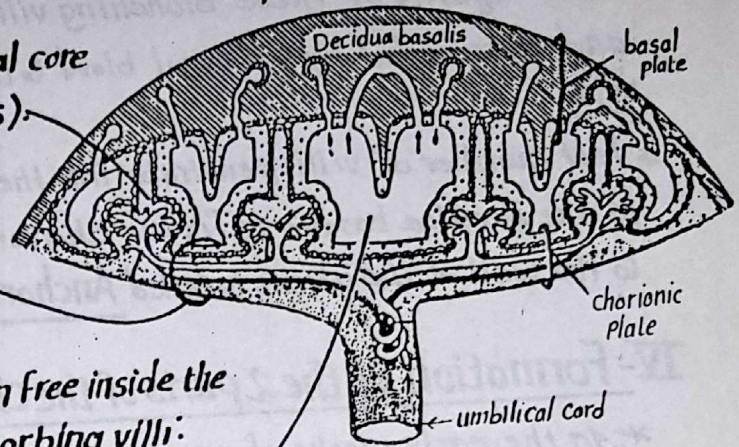
the internal structure presents the following components:

- (1) chorionic villi.
- (2) intervillous spaces.
- (3) cytotrophoblastic shell.
- (4) placental septa & cotyledons.
- (5) placental barrier.

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(1) Chorionic Villi :

- it is of the tertiary type (containing a central core of extra embryonic mesoderm & blood vessels).
- the area of the chorion to which these villi are attached is called the chorionic plate.
- the villi which get attached to the decidua basalis are called anchoring or stem villi.
- the side branches of the stem villi which remain free inside the intervillous spaces are called floating or absorbing villi.

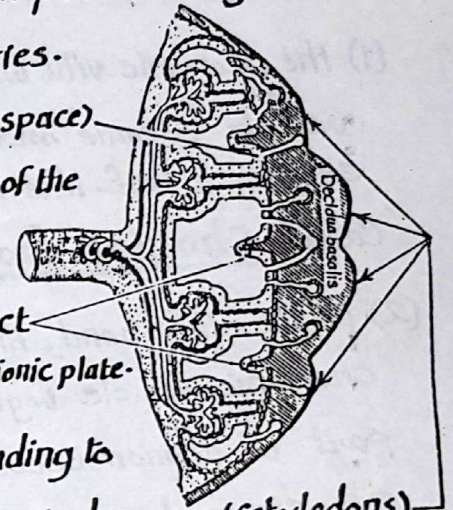


(2) Intervillous space : (the space between the villi):

- it lies between the basal plate (forming its roof) & the chorionic plate (forming its floor).
- it is filled with maternal blood coming from the maternal arteries.

(3) Cytotrophoblastic shell: (lies in the roof of the intervillous space)

- it is formed at the basal plate, by fusion of the cytotrophoblast of the adjacent anchoring villi to form a continuous sheet.



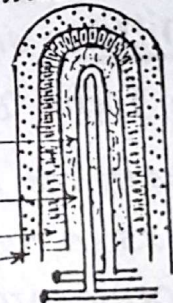
(4) Placental septa: are finger-like processes which project from the roof of the intervillous space but do not reach the chorionic plate.

(5) Cotyledons : the bases of the placental septa are corresponding to grooves on the outer surface of decidua basalis bounding elevated masses (cotyledons)

(6) Placental Barrier : it means the layers of the villous wall which separate the foetal blood (in the capillary loop of the floating villus) from the maternal blood (in the intervillous space).

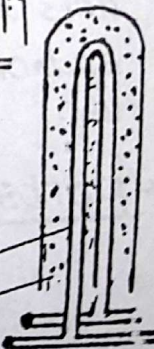
- A- In early pregnancy, the placental barrier is formed of 4 layers

- (1) the endothelial lining of the capillary loop in the villus.
- (2) extra-embryonic mesoderm in the core of the villus.
- (3) a layer of cyto-trophoblast.
- (4) a layer of syncytio-trophoblast.



(B) In late pregnancy: at the 4th month, the placental barrier is reduced in thickness (to allow easier exchange of gases & nutrient substances) & becomes composed of 2 layers only

- (1) endothelium of the capillary loop
- (2) the syncytio-trophoblast



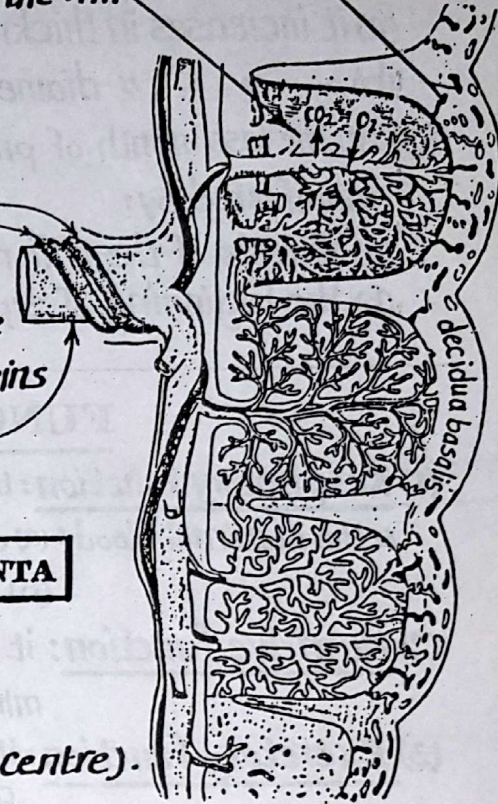
* Placental circulation: has 2 Components:

(A) Maternal circulation in the placenta:

maternal blood (oxygenated) passes from the spiral arterioles of the decidua basalis to the intervillous spaces between the villi then leaves via numerous thin-walled decidual veins.

(B) Foetal Circulation in the placenta:

- the deoxygenated foetal blood reaches the placenta via the branches of the 2 umbilical arteries.
- the blood flows through the arterioles then the capillary loops inside the villi where exchange of gases takes place
- oxygenated blood returns to the foetus via venules & veins which join one another & drain into the umbilical vein.



GROSS MORPHOLOGY OF THE PLACENTA

The full-term placenta has the following features:

* Shape: circular disc.

* Size: 15-25 cm in diameter & 3 cm thick (in the centre).

* Weight: about $\frac{1}{2}$ kg.

* Surfaces: It has 2 surfaces: foetal & maternal

Foetal Surface	Maternal Surface
branches of umbilical vessels seen through the amnion amnion (cut) umbilical cord	cotyledons decidua basalis removed to show underlying chorionic villi
* It is directed inwards (towards the foetus)	directed outwards towards the uterine wall
* Formed by the chorionic plate	formed by the decidua basalis
* Very smooth & covered by the amnion. The umbilical cord is attached near the centre of the foetal surface & the umbilical vessels are seen diverging from the site of attachment.	rough & irregular. It is divided by grooves into 15-20 slightly elevated areas called cotyledons.

* Growth of the placenta:

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- (1) the placenta becomes completely formed by the 3rd month.
- (2) From the 3rd month onwards, the placenta grows in size as follows :
 - (a) it increases in thickness by elongation of the villi & widening of intervillous spaces.
 - (b) " " " diameter secondary to the growth of the uterine wall.
- (3) At the last month of pregnancy, the placenta undergoes degeneration which is manifested by:
 - (a) fibrosis of the villi resulting in reduction of the placental functions.
 - (b) the beginning of separation of the placenta from the wall of the uterus.

FUNCTIONS OF THE PLACENTA

- (1) Respiratory function: the placenta allows exchange of gases between the foetal blood & the maternal blood :
 - (a) oxygen diffuses from the maternal blood to the foetal blood.
 - (b) CO₂ " " " foetal blood to the maternal blood.
- (2) Nutritive function: it allows the passage of nutrient substances, vitamins & minerals from the maternal blood to the foetal blood.
- (3) Excretory function: it allows the diffusion of the nitrogenous products e.g urea from the foetal blood to the maternal circulation.
- (4) Secretory (endocrine) function: the placenta secretes the following hormones:
 - (a) progesterone: is secreted starting from the end of the 4th month. This hormone is essential for the maintenance of the normal pregnancy.
 - (b) oestrogen : reaches the maximal secretion at the end of pregnancy. It increases the sensitivity of the uterus to the oxytocin hormone
 - (c) Chorionic gonadotrophins: have action similar to the L.H. hormone of the pituitary gland. They pass to the maternal blood → urine (used for testing the occurrence of pregnancy).
 - (d) Melanin spreading factor: responsible for pigmentation of skin of certain areas in the pregnant mother.
- (5) protective function: the placental barrier has the following functions:
 - (a) it prevents the passage of most (but not all) microorganisms to the foetus. Certain viruses (e.g Aids & German measles) & bacteria (e.g syphilis) can, however, cross the placental barrier & infect the foetus.
 - (b) it prevents mixing of maternal blood cells with the foetal blood cells.
 - (c) it permits the passage of antibodies against some diseases from the maternal to the foetal circulation.

(A) Abnormalities in size & shape:

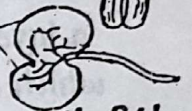
(1) Diffuse placenta (*placenta membranacea*): the placenta lines the greater part of the uterine cavity. It is due to the persistence of the chorionic villi of the chorion laeve (both chorion frondosum & laeve share in the formation of the placenta).



(2) Accessory placenta (*placenta succenturiata*): the placenta has one or 2 accessory lobes completely separate from the main placenta.



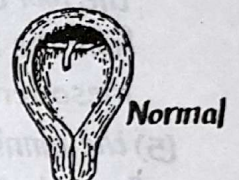
(3) Bidiscoid placenta: the placenta is formed of 2 disc-like equal parts, each of which receives a branch from the umbilical artery.



(4) Placenta accreta: a placenta which shows abnormal fixation to the wall of the uterus. It is due to extensive invasion of the stem villi to the myometrium.

(B) Abnormalities of position:

* Normally, the implantation occurs in the post. wall of the fundus & the placenta develops in the upper part of the uterus.



* If implantation occurs in the lower part of the uterus, the placenta develops in the lower uterine segment & is called placenta previa.

* Types of placenta previa: according to its relation to the internal os of the cervix, placenta previa is classified into 3 types:

(1) placenta previa lateralis: the placenta encroaches on the lower uterine segment but does not reach the internal os.



(2) " " marginalis: the margin of the placenta overlies the internal os of the cervix.



(3) " " centralis: the centre of the placenta overlies the internal os of the cervix.



N.B: placenta previa is a dangerous abnormality leading to premature separation of the placenta from the uterine wall before labour which results in ante-partum haemorrhage (i.e. before labour).

(C) Abnormal attachment of the umbilical cord to the placenta:

see page 46.

The Amnion

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* **Definition** : it is a membrane which bounds the amniotic cavity & is continuous with the ectodermal germ layer at the amnio-ectodermal junction.

* **Early development of the amnion & amniotic cavity** :

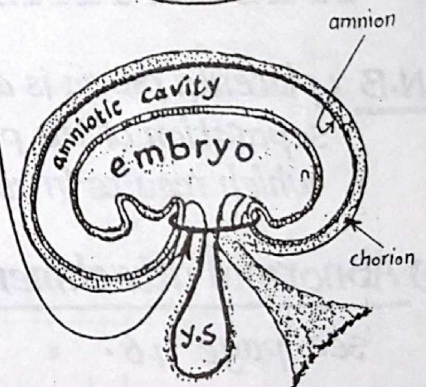
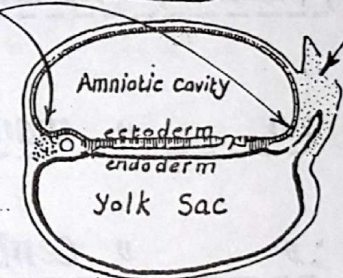
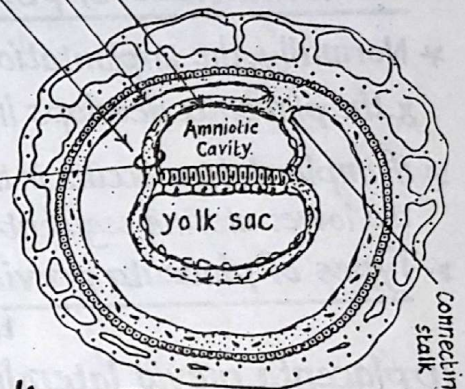
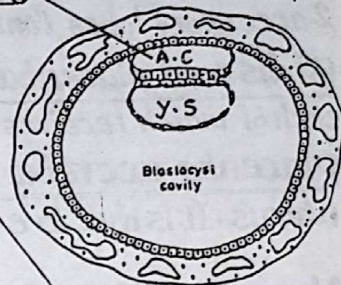
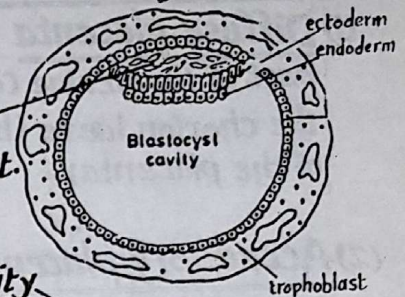
(1) the amniotic cavity starts to appear in the 7th day as small intercellular clefts between the ectodermal cells & the trophoblast.

(2) the clefts soon unite together forming a small space between the trophoblast & the ectoderm called the amniotic cavity.

(3) the amniotic cavity enlarges in size & becomes roofed by a layer of flattened cells called the amnioblasts which develops from the inner surface of the trophoblast.

(4) after the formation of the extraembryonic mesoderm & the development of the extraembryonic coelom inside it the roof of the amniotic cavity becomes separated from the trophoblast by a mass of extraembryonic mesoderm called the connecting stalk (body stalk).

(5) the amniotic cavity is now bounded by a membrane formed of amnioblasts + extraembryonic mesoderm & is called the Amnion.



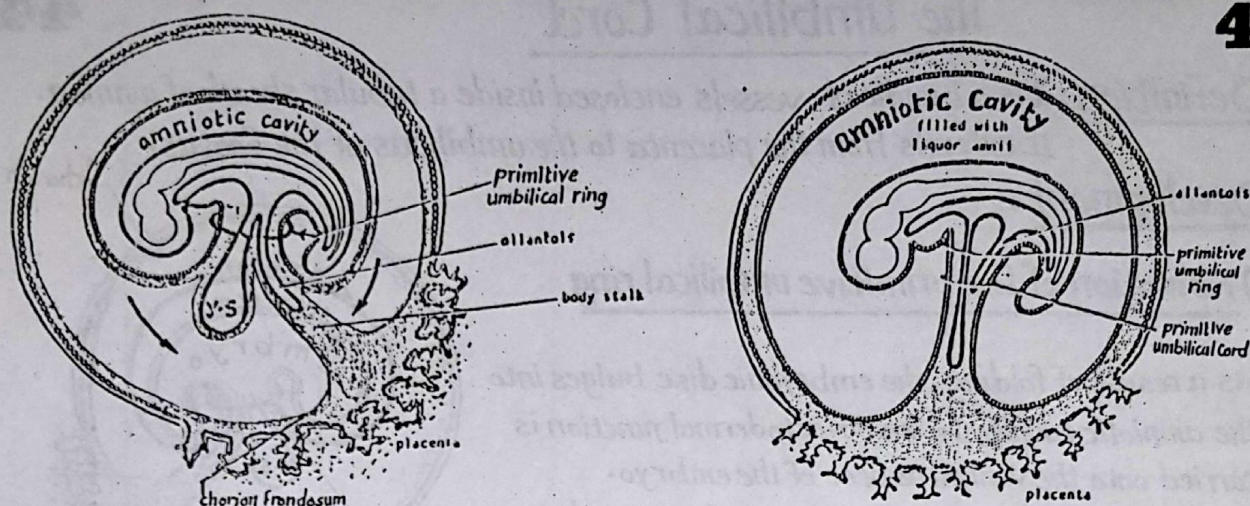
* **Formation of the primitive umbilical ring** :

(1) At first, the amnio-ectodermal junction is continuous with the periphery of the ectodermal layer of the embryonic disc.

(2) as folding occurs, the embryonic disc bulges into the amniotic cavity & the amnio-ectodermal junction becomes carried to the ventral aspect of the embryo & becomes oval in shape & is called the primitive umbilical ring.

* **Enlargement of the amniotic cavity & obliteration of the extra embryonic coelom** :

- as pregnancy advances, the amniotic cavity enlarges rapidly & by the 3rd month it surrounds the embryo almost completely.
- the amnion finally comes in contact with the chorion thus obliterating the extra embryonic coelom.



The Amniotic Fluid

* **Nature** : it is the watery fluid filling the amniotic cavity.

* **Source** : it is secreted by the amnioblast cells. It also receives urine secreted by the foetal kidneys.

* **Amount** : 1 – 1.5 liters (at the end of pregnancy).

* **Functions of the amniotic fluid** :

- (1) acts as protective watery cushion around the embryo (protects against trauma & external pressure).
- (2) prevents adhesions between the embryo & the amnion & also between the different parts of the foetus.
- (3) keeps constant temperature around all parts of the body of the embryo.
- (4) allows free movements of the embryo thus encourages the development of the muscles.
- (5) provides a space for the accumulation of foetal urine & meconium (a dark green discharge which comes out of anal canal before birth & few days after birth).
- (6) protects the foetus against the strong uterine contractions occurring late in pregnancy.
- (7) the foetus begins swallowing of the amniotic fluid. This helps the development of the suckling reflex.
- (8) It has important functions at the end of pregnancy & during labour :
 - (a) at the beginning of labour the amniotic cavity bulges downwards into the cervix forming the "bag of waters" which helps to dilate the cervix gently.
 - (b) just before birth, the amnion ruptures liberating the amniotic fluid which has an antiseptic nature (washes the vagina).

* **Abnormalities of the amniotic fluid** :

- (1) Oligohydramnios : the volume of the amniotic fluid is less than $\frac{1}{2}$ litre. This may lead to adhesions between the embryo & the amnion.
- (2) Polyhydramnios : the volume of the amniotic fluid is more than 2 litres. This may lead to premature rupture of the amnion.

The Umbilical Cord

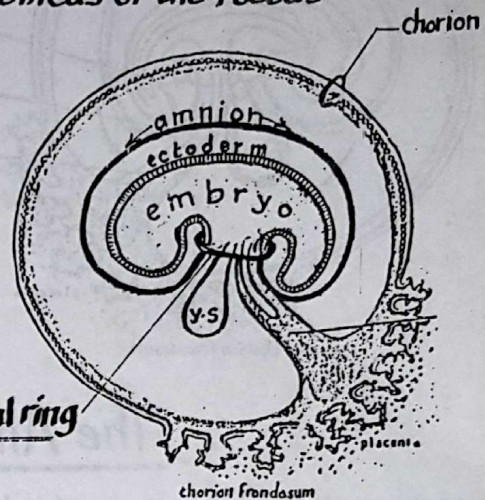
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* Definition: it is a bundle of vessels enclosed inside a tubular sheath of amnion. It extends from the placenta to the umbilicus of the foetus.

* Development:

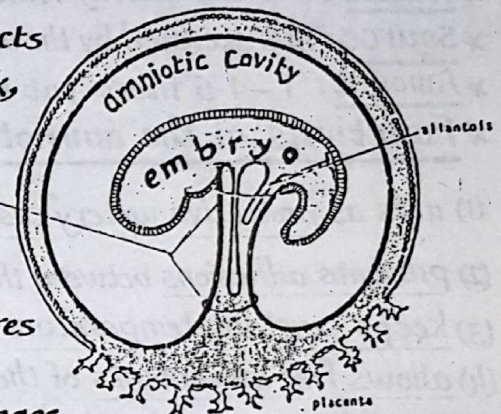
(I) Formation of the primitive umbilical ring

- as a result of folding, the embryonic disc bulges into the amniotic cavity & the amnio-ectodermal junction is carried onto the ventral aspect of the embryo.
- the line of reflection between the amnion & ectoderm acquires an oval outline & is called the primitive umbilical ring



(II) Formation of the primitive umbilical cord:

- By the 5th week, the primitive umbilical ring constricts to form a tubular sheath which encloses the body stalk, the yolk sac & its vessels & part of the allantois. This tubular sheath is called the primitive umbilical cord



(III) Formation of the definitive umbilical cord:

- the umbilical cord elongates & its constituent structures undergo changes as follows:
 - (1) the extra embryonic mesoderm of the body stalk changes to a mucoid substance called "Wharton's jelly" (forms the main bulk of the cord).
 - (2) the remnants of extra-embryonic coelom inside the cord gradually disappears
 - (3) the yolk sac becomes obliterated together with the vitello intestinal duct connecting the yolk sac to the midgut.
 - (4) the distal part of the allantois becomes obliterated while its vessels persist & elongate to form the umbilical vessels.
 - (5) at the 6th week, a part of the midgut loop enters the umbilical cord (physiological hernia) then returns again to the abdominal cavity after the 10th week.

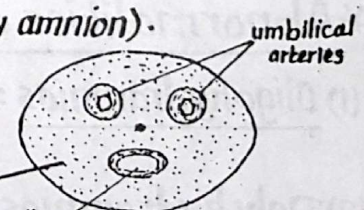
Anatomical features of definitive U-cord

* Shape: soft tortuous cord having a smooth surface (covered by amnion).

* length: 50-60 cm long & 1 cm. in diameter.

* Structure: it is formed of outer covering of amnion enclosing:

- (a) gelatinous ground substance (Wharton's jelly)
- (b) 3 vessels: 2 umbilical arteries & one umbilical vein
- (c) remnant of the allantois



* Attachments: it is attached between the umbilicus of the foetus & the placenta (near its centre).

Abnormalities of the Umbilical cord

(1) Very short cord: may cause premature separation of the placenta or the cord itself may rupture.

(2) Very long cord: may wind around the neck of the foetus causing its death or may prolapse from the cervix.

(3) Exomphalos: the umbilical cord is distended & contains loops of the midgut (small intestine) it is due to failure of reduction of the physiological umbilical hernia.

(4) Abnormal attachment of the cord to the placenta:

(a) eccentric attachment of the umbilical cord:

(b) marginal attachment of the cord (battledore placenta)

(c) Velamentous attachment of the cord: the cord does not reach the placenta but ends in the surrounding membranes.

(5) Abnormal structure of the cord:

the cord may contain one umbilical artery only (instead of 2) this may lead to congenital malformations.

(6) Knots of the umbilical cord: are of 2 types:

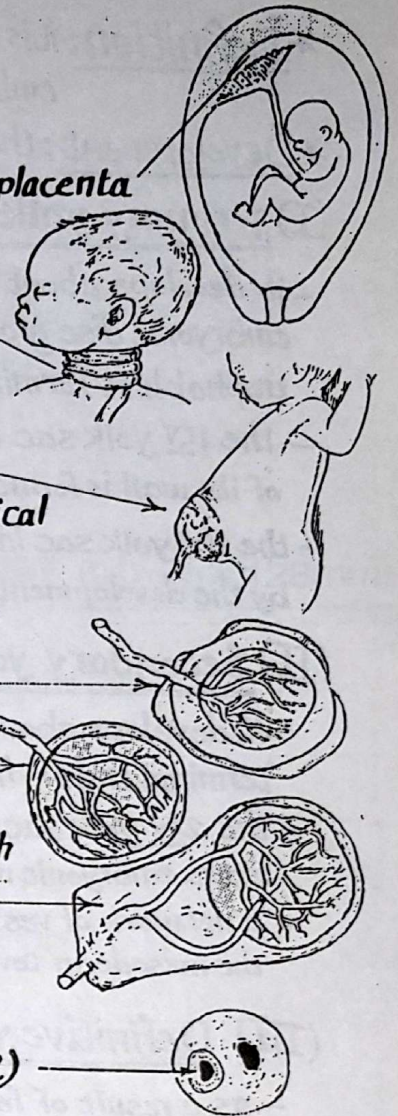
(A) False knots: these are bulgings on the surface of the cord due to excessive tortuosity of the umbilical vessels. They are not dangerous to the foetus (normal).



(B) True knots: are very dangerous because they may cause obstruction of the blood flow in the umbilical vessels leading to death of the foetus.



(7) Double or triple umbilical cord.



YOLK SAC

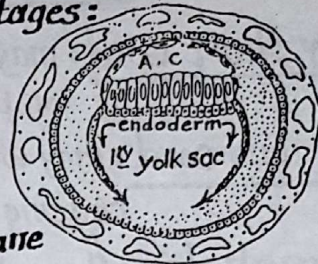
46

* Definition: it is a cavity which develops on the ventral surface of the embryonic disc & is roofed by the endodermal germ layer.

* Development: the yolk sac develops in the following stages:

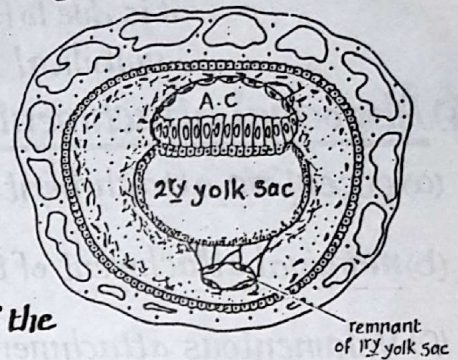
(I) Primary yolk Sac:

- it develops about the 9th day when the endoderm of the embryonic disc grows down on the inner surface of the trophoblast forming a membrane called Heuser's membrane
- the 1st yolk sac is thus roofed by the endodermal germ layer while the rest of its wall is formed of Heuser's membrane with its covering extraembryonic mesoderm.
- the 1st yolk sac later separates from the trophoblast by the development of the extraembryonic coelom.



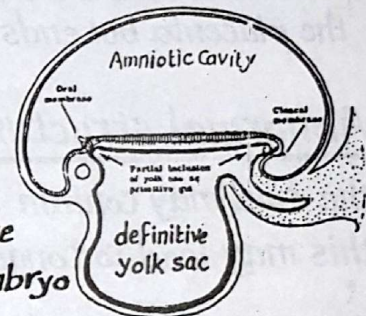
(II) Secondary yolk Sac:

- it develops about the end of the 2nd week when the terminal end of the 1st yolk sac becomes cut-off
- the 2nd yolk sac is covered by the splanchnic layer of the extraembryonic mesoderm
- a network of vessels (called vitelline vessels) develop in the mesoderm covering the 2nd yolk sac

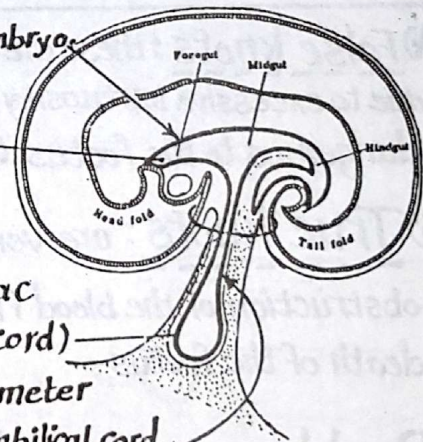


(III) Definitive yolk sac:

- as a result of folding of the embryonic disc, the roof of the 2nd yolk sac becomes enclosed inside the body of the embryo
- the 2nd yolk sac is thus divided into 3 parts:



- the primitive gut: is the part inside the body of the embryo which becomes subdivided into 3 parts
 - foregut: inside the head fold of the embryo.
 - hindgut: " " tail " " " "
 - midgut: inbetween the foregut & the hindgut.



- the definitive yolk sac: is the part of the yolk sac lying outside the embryo (inside the umbilical cord) it grows very slowly (never exceeds 1/2 cm. in diameter) then shrinks to form a small body lying inside the umbilical cord.

- the yolk sac stalk (vitello-intestinal duct): connects the primitive gut with the definitive yolk sac. Later on, it becomes completely obliterated.

* Functions of the yolk sac:

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- (1) the primitive gut is derived from the roof of the yolk sac.
 - (2) the allantois is derived from the caudal part of the yolk sac (see below).
 - (3) the primordial germ cells (spermatogonia or oogonia) arise from the caudal wall of the yolk sac then migrate to enter the developing gonads of the embryo.
 - (4) Blood is formed in the mesoderm of the wall of the yolk sac during the 3rd, 4th, 5th & 6th weeks.
 - (5) the Vitelline vessels (of the yolk sac) form some of the embryonic vessels.
- N.B: the yolk sac has **No nutritive function in man**: although it is called "yolk" sac, yet it does not contain any yolk.

The Allantois

* Definition: it is a tubular invagination of the dorso-caudal part of the yolk sac into the connecting stalk.

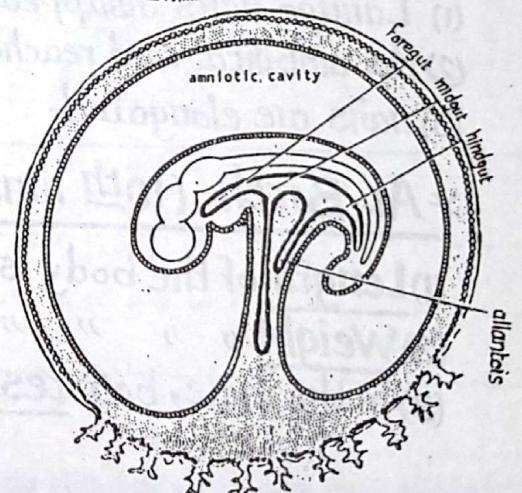
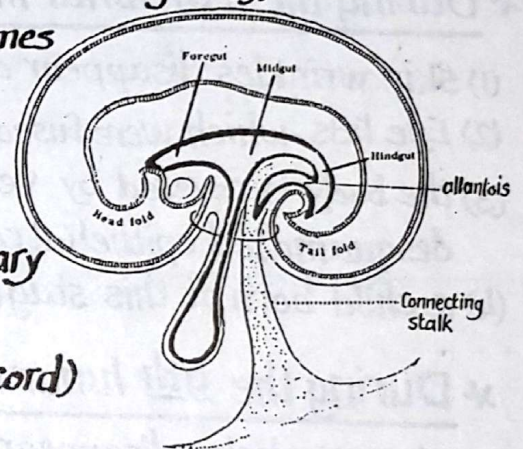
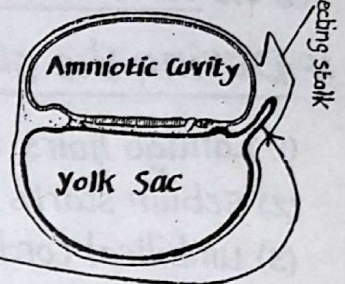
* Development:

- (1) it develops during the 3rd week as a tubular invagination from the dorso-caudal part of the yolk sac which extends into the connecting (body) stalk.
- (2) When the hindgut is formed, the allantois becomes connected to the ventral aspect of the cloaca.
- (3) the allantois has 2 parts:

- (a) an intra-embryonic part (inside the embryo) which forms the urachus that connects the urinary bladder to the umbilicus.
- (b) an extra-embryonic part (inside the umbilical cord) which becomes obliterated.

* Significance of the allantois:

- (1) the proximal part of the allantois enters in the formation of the urinary bladder while its distal part (the urachus) is obliterated forming the median umbilical ligament which extends from the apex of the urinary bladder to the umbilicus.
- (2) the allantoic vessels form the umbilical vessels.

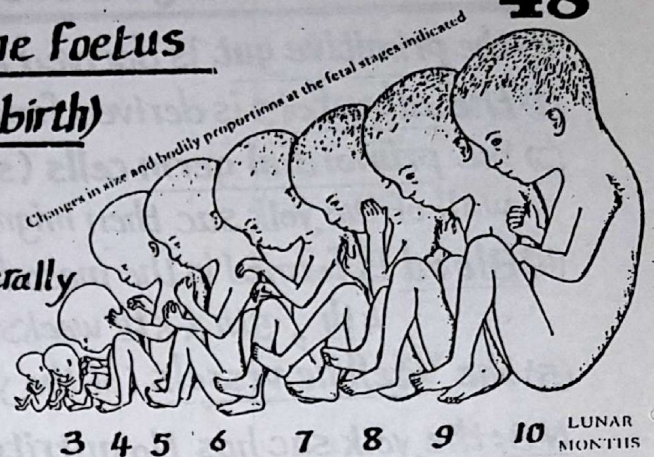


External Features of the Foetus

(From the 3rd month till birth)

* During the 3rd lunar month:

- (1) the face acquires the human appearance:
 - (a) the eyes are directed forwards instead of laterally
 - (b) „ ears are directed laterally.
- (2) Nails appear on the back of finger tips.
- (3) umbilical hernia is reduced & the umbilical cord is attached near the symphysis pubis.



- (4) the sex of the Foetus can be distinguished by inspection of the external genitalia.

* During the 5th lunar month:

- (1) Lanugo hairs cover most of the body.
- (2) Sebum starts to be secreted by the sebaceous glands.
- (3) umbilical cord migrates cranially away from the symphysis pubis.
- (4) Movements of the foetus can be felt by the mother (this is called quickening).

* During the 7th lunar month:

- (1) skin wrinkles disappear due to deposition of fat under the skin.
- (2) Eye lids, which were fused, become now separate from each other.
- (3) the body is covered by vernix caseosa (composed of sebum mixed with desquamated epithelial cells).
- (4) a child born at this stage can survive.

* During the 9th lunar month:

- (1) Lanugo hairs disappear (except over the scapulae).
- (2) the umbilical cord reaches the centre of the abdomen.
- (3) nails are elongated.

* At Birth (10th lunar month):

- (1) Length of the body is about 50 cm (from head to heel).
- (2) Weight „ „ „ „ 3 - 3½ kg.
- (3) in the male, both testes are present in the scrotum.

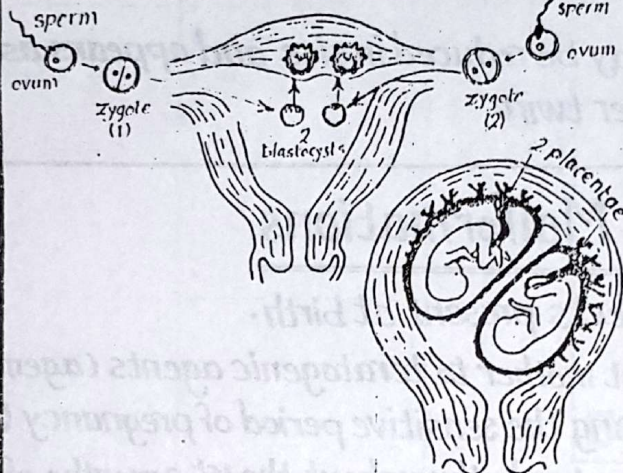
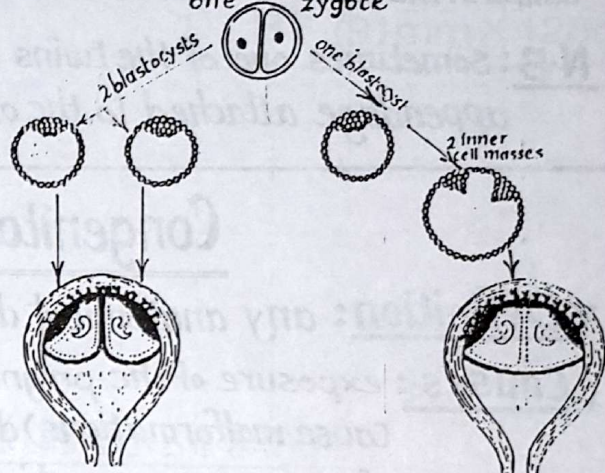


* Incidence:

- (1) Twins (2 embryos): occur approximately once in every 80 births.
- (2) Triplets (3 embryos): " " " " " 80² "
- (3) Quadruplets (4 embryos) " " " " " 8³ "
- (4) 5 or 6 embryos may also occur but very rare.

DEVELOPMENT OF TWINS

- * Types:
 Dizygotic: result from fertilization of 2 separate ova
 Monozygotic: result from division

	Dizygotic (Binovular) twins	Monozygotic (uniovular) twins
		
Incidence	more Common (70 % of twins).	less common (30 % of twins).
Mechanism of development	they result from the fertilization of 2 ova which are discharged simultaneously from the 2 ovaries during an ovarian cycle by 2 separate sperms	they result from the division of a single fertilized ovum (zygote) during one of the following stages of development: (a) at the 2-cell stage where each cell will develop into a separate embryo or (b) at the stage of the blastocyst where the inner cell mass divides into 2 parts, each of which forms an embryo
Placenta	2 separate placentae	single common placenta
Chorion	2 separate chorionic sacs	Single common chorionic sac.
Sex	may be of the same or different sex	always of the same sex
Features	the twins have different features due to different genetic constitution because they develop from 2 separate zygotes.	they are exactly identical (except for finger prints) & have the same genetic constitution as they develop from one zygote.

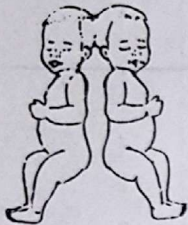
Conjoined (siamese) Twins

50

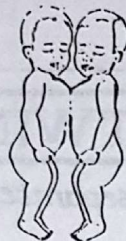
* Definition : they are fused monozygotic twins.

* Cause : incomplete splitting of the 2 inner cell masses of the monozygotic twins

* Types : according to the site of fusion, the conjoined twins are classified into the following types :



(1) Craniopagus
united in the head



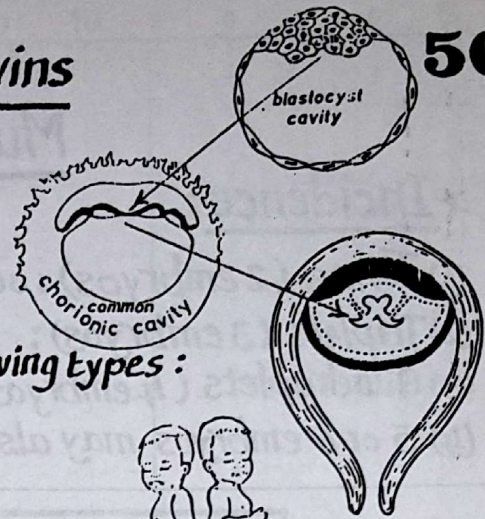
(2) thoracopagus
united in the chest



(3) xiphopagus
united in the abdomen



(4) pyopagus
united in the sacral region



N.B : Sometimes one of the twins may be reduced in size and appears as an appendage attached to the other twin.

Congenital Malformations

* Definition : any anatomical defects present at birth.

* Causes : exposure of the pregnant mother to teratogenic agents (agents which cause malformations) during the sensitive period of pregnancy (the period of organogenesis which extends throughout the 1st 3 months of pregnancy).

the teratogenic agents may be :

(1) physical agents : e.g radiations as x-ray, gamma rays & electrons

(2) chemical : e.g some drugs as thalidomide & hormones.

(3) mechanical : pressure on the foetus especially in association with oligohydramnios.

(4) Infectious agents : e.g the virus of German measles & the bacteria of syphilis.

* Mechanisms : teratogenic agents produce malformation through :

(1) production of gene mutations or chromosomal aberrations.

(2) interference with the action of the organizers which stimulate the differentiation of tissues, leading to failure of formation of the related organs (agenesis).

(3) arrest of the growth of developing organs leading to incomplete formation (hypogenesis).

(4) interference with the normal differentiation leading to the development of malformed organs.